Carroll County
Floodplain Management Manual

July 2015 Edition

Department of Land and Resource Management
Bureau of Resource Management
225 North Center Street, Westminster, Maryland 21157

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Carroll County
Floodplain Management Manual

SECTION 1 OVERVIEW

Sect. 1.1 Introduction

The Carroll County Floodplain Management Manual (the Manual) is intended to be a companion to and be used in conjunction with the Carroll County Floodplain Management Chapter 153 of the Code of Public Local Laws and Ordinances of Carroll County (the Code).

Sect. 1.2 Purpose

The purpose of the Manual is to set clear guidelines, technical standards, and submission procedures for floodplain studies. Furthermore, the Manual is to provide effective implementation of Chapter 153 by setting minimum technical standards for performing floodplain studies and producing consistent, accurate, current, and verifiable floodplain mapping. This mapping can be used to evaluate flood hazards, set flood insurance rate zones, and regulate new subdivision and building construction in and around floodplains.

Sect. 1.3 Objective

Carroll County's long-term objective is to create current, accurate floodplain mapping for all of Carroll County, available to all interested parties, on the County's Geographic Information System (GIS). This will enable prospective and existing property owners, lending institutions, and insurers to avoid buying, building, financing, or insuring property, homes, or businesses subject to flood hazards. The floodplain technical standards must be consistently applied to all projects.

SECTION 2 DEFINITIONS

Sect. 2.1 Definitions

Cross-Section – The ground line measured and plotted perpendicular to the flow of water.

Development - The subdivision of land; any man-made change to improved or unimproved real estate, including but not limited to buildings, or other structures, mining, dredging, filling, grading, paving, excavation or storage of materials and equipment.

Flood Insurance Rate Map or FIRM – A map that depicts the minimum special flood hazard area to be regulated by Chapter 153.

Floodplain – That land adjacent to a body of water or stream inundated by the base flood.

Hydraulic Cross-Section – A ground line perpendicular to the flow of water including the stream and associated floodplain up to the 100-year WSEL.

Hydraulic Structure – A conveyance structure for water i.e.: bridges, culverts, pipes, dams, spillways, levies, chutes, channels, etc.

NAVD - North American Vertical Datum elevation reference points set by the National Geodetic Survey based on mean sea level.

One Hundred (100) Year Storm Event – A storm that has a one per cent (1%) chance of being equaled or exceeded in any given year, as determined by the National Oceanographic and Atmospheric Administration and the National Weather Service.

Stream – A part of a watercourse either naturally or artificially created that contains intermittent or base flow of groundwater origin, but not including a ditch that conveys surface runoff exclusively from storm events.

Structure - A building or water conveyance, including but not limited to bridges, dams, culverts, dikes, flumes, or levees. That which is built or constructed; specifically, a walled and roofed building, including a gas or liquid storage tank that is principally above ground, as well as a manufactured home.

Variance - The grant of relief from a term or terms of Chapter 153.

SECTION 3 SUBDIVISION / SITE PLAN REVIEW AND APPROVAL

A. Subdivision / Site Plan – Plans submitted through the subdivision/site plan process must meet the requirements of Chapter 153.

1. Concept Plan

a. Delineate all on site and immediately adjacent streams and FEMA or previously identified floodplains.

b. Approximate location of fills, grading, and structures that are proposed within streams or potential floodplains.

2. Requirements for Preliminary Plan Approval

a. All on-site existing and proposed floodplains shall be determined and shown on the construction plans along with floodplain, stream buffer and dam breach inundation areas.

b. Impacted Floodplains / Streams

1.) Alternative Analysis submitted.

2.) FEMA Community Acknowledgement form signed by the Board of County Commissioners.

3.) Conditional letters of map revision (CLOMR) issued by FEMA.

c. All requirements of this Manual met.

3. Requirements for Final Plan Approval

a. Copies of all required State and Federal approvals received by County.

b. Recommendation for fill variance per Chapter 38 for any impacted floodplain obtained.

c. Variance to the technical requirements issued by Carroll County pursuant to § -153.081 of the Code for impacts to floodplains / streams.

d. Grading permit approved by Carroll County.

e. Easements deeded to the appropriate jurisdictions

1.) Subdivision – Floodplain, buffer and dam breach inundation easements included on a Plat.

2.) Off-Conveyance/Site – Floodplain, buffer and dam breach inundation easements included on either a Plat, or on an Exhibit Plat that is attached to a Metes & Bounds description.

f. Final plan approval.

4. Requirements for Construction and Building Permits

a. Grading, filling, and construction of hydraulic structures in all impacted floodplains / streams completed.

b. As-Built surveys conducted, certified As-Built drawings and calculations submitted to FEMA and / or Carroll County within 60 days of 4a.

c. FEMA letter of map revision (LOMR) issued and copies submitted to Carroll County.

d. Bureau of Resource Management sign-off on building permits.

Sect. 4.1 Study Criteria

Floodplains must be delineated by the following methods:

A. Hydrology by TR-55 or TR-20. Hydraulics by the alternative "simplified" method or HEC-RAS. Existing FEMA studies performed using the HEC-2 may be modified using the same program. No new HEC-2 studies will be accepted.

B. Floodplain studies previously completed for land development purposes may be used when the following conditions are met:

1. The study must contain information that is current enough to justify the floodplain determination and be computed by acceptable methods.

2. The previously approved study on file with the County cannot be referenced. The applicant must include copies of the appropriate portion of the previous study.

The County reserves the right to reject or require modifications to a study regardless of the previous acceptance of the study by any agency.

C. Study Types:

1. Unmapped County Floodplains.

a. The alternative "simplified" method, with ultimate condition hydrology.

2. Approved FEMA Floodplains

a. In areas where no development has or is proposed to occur in the floodplain, the alternative "simplified" method, with ultimate condition hydrology, should be used to develop Base Flood Evaluations (BFE's).

b. In areas where development has or is proposed to occur with modifications to the mapped FEMA floodplain, they must be updated and revised through the CLOMR/LOMR process. HEC-RAS studies are required. Ultimate condition hydrology is required for County review and approval. FEMA requires pre- and post-development hydrology.

c. Detailed FEMA floodplains shall be revised using the existing FEMA approved hydrology. The existing hydraulic models shall be revised and updated to accurately reflect all encroachments and hydraulic structures that have been constructed since the original study. The revised floodplain boundary shall be delineated and approved by Carroll County and FEMA through the LOMR process.

3. Detailed FEMA Floodplain

a. In areas where development has or is proposed to occur with modifications to mapped FEMA floodplain, they must be updated and revised through the CLOMR/LOMR process. HEC-RAS studies are required. Ultimate condition hydrology is required for County review and approval. FEMA requires pre- and post-development hydrology.

b. In areas where development has or is proposed without modification to the effective FEMA floodplain, both the delineation per the effective FIRM and the delineation per elevations from the FIS profile shall be shown on the plan. Easements must protect the more conservative or combination thereof.

c. Where it can be demonstrated that existing FEMA discharges are reasonably correct, the detailed FEMA floodplain shall be revised using the existing FEMA approved hydrology. The floodplain must be updated/revised per Section 4.1.C.3.a.

Sect. 4.2 General Requirements for all Floodplain Studies

A. Subject to approval by Carroll County.

B. Studies shall be consistent with applicable State and Federal regulations. i.e.: Where FEMA maps exist, the water surface elevations as shown on the Flood Insurance Rate Maps will be minimum acceptable starting water surface elevations for existing conditions. (Subject to approval by Carroll County).

C. Prepared by a registered professional engineer or land surveyor licensed to practice in the State of Maryland, sealed, signed and dated.

D. Conform to criteria published herein.

E. Based on 100-year flood event, for the ultimate development; in keeping with the land use conditions as specified in the plan or the most updated zoning map within the watershed, whichever is more restrictive. Except as noted in Section 4.1.C.2.c.

F. Valid hydrologic analysis of rainfall, runoff, and conveyance.

G. If storage effects are significant, volume as well as peak flow must be evaluated.

H. Limits of 100-year floodplain before and after development shown on site and subdivision plans.

I. The applicant must acquire floodplain easements on areas outside the property limits that are affected by any water surface rise resulting from the development.

If no ultimate floodplain is on record, the before and after differential needs to be established and floodplain easements acquired. The easements shall be recorded in the Land Records of Carroll County. All floodplain easements shall be platted. If the ultimate floodplain is on record and the property development causes any further increase, then the differential shall be accommodated in an easement. Existing condition floodplains may be used in place of ultimate condition floodplains in the circumstances noted in Section 4.1.C.2.c.

J. The applicant must acquire dam breach inundation easements on areas outside the property limits that would be inundated by the collapse of a dam constructed as part of the development. All areas outside the property limits are required to be included and delineated. The easements shall be recorded in the Land Records of Carroll County. All dam breach inundation easements shall be platted.

K. Consider backwater conditions and local obstructions.

L. The ultimate floodplain study for existing or proposed conditions will not be approved until Carroll County reviews the associated construction plans.

M. Conform to any other requirements as required by the appropriate approval agencies.

N. If lots in a proposed subdivision are served by a common-use-drive, any lot not provided access above the FPE shall be noted on the plat as follows:

1. The use-in-common driveway shown hereon, known as (**drive name**), may be subject to flooding and therefore is not eligible for county road status. Lots (**give lot numbers**) are not provided with flood-free access.

O. If floodplains considered to be exempt exist within the remainder or remaining portion, the following note must be added to the plat or recorded with the deed in the Land Records of Carroll County:

1. Although no floodplain easement is depicted, a floodplain does exist on the remainder or remaining portion.

Sect. 4.3 Report

A report must be submitted with all floodplain studies. The report shall include a general description of the project and a written summary of the computational methodology.

A. Brief description of existing site conditions;

B. Copy of appropriate FEMA floodplain panel with the property shown to scale;

C. A detailed description of proposed site conditions including a copy of the development plan;

D. If channel modifications are proposed, a copy of the design plans shall be included;

E. Explanation of all assumptions made in computations. Reference computational procedures and equations;

F. Explanation of how the hydraulic cross-section information was generated. (Field survey or aerial topographic map with minimum 2-foot contour intervals, etc.);

G. Explanation of how the starting water surface elevation was determined;

H. Ranges of Manning's "n" values for both channel and overbanks as found in appendix 1. any other values must be presented to and approved by the County.

I. Any other pertinent information that will aid in the review process (correspondence, intra / inter-agency agreements, etc.).

Sect. 4.4 Hydrology

A. Applicability:

1. This Section does not apply to studies performed in areas that meet the criteria of Section 4.1.C.2.c (detailed FEMA floodplains).

2. Section 4.4.B.6 or 7 and Section 4.4.C.4 and 5 do not apply to studies performed in areas that meet the criteria of Section 4.1.C.1.a (Unmapped County Floodplains). In these areas with prior County agreement, requirements in Section 4.4.C.1, 2, and 3 may be simplified to a single drainage area, composite runoff curve number and Time of Concentration path.

B. General Hydrologic Study Requirements:

1. Drainage area map identifying each sub-watershed and the flow path used for the Time of Concentration (Tc) calculations with all segments labeled;

2. Back-up calculations for the Tc determination;

3. Soil map with sub-watershed boundaries drawn on it;

4. Zoning map and land use map with sub-watershed boundaries drawn on it (the worst case shall govern in generation of expected runoff);

5. Watershed TR-20 Schematic;

6. Back-up calculations for stage-discharge and discharge-area relationships for the channel routing rating tables; and

7. Back-up calculations for stage-discharge and stage-storage relationships for the reservoir routing rating tables.

C. Specific Hydrologic Study Requirements:

1. Drainage area maps should show existing and proposed topography with sub-watersheds delineated. (As a minimum, USGS or quadrangle maps may be used). The County reserves the right to require more detailed topography for drainage area maps.

2. Runoff Curve Numbers (RCN) must be computed based on ultimate land use taken from the most recent zoning map, existing development, and/or the proposed site or subdivision map; whichever, generates the greatest runoff. The soil types shall be based on the Carroll County Soil Survey (Making the assumption that the land will remain undeveloped is unacceptable). In drainage areas where the existing zoning is agricultural, the lot yield is one lot per 20 acres. Likewise, conservation zoned areas have a lot yield of one lot per three acres. To establish the maximum ultimate conditions RCN, the available lots should be assumed to be one acre in size. The lots should replace woods first, meadow second, and row crop agricultural lands last if all other areas have been exhausted.

3. Time of Concentration (Tc) must be calculated following the procedures outlined in the latest edition of the TR-20 and shall include the following:

   a. The flow path segments used to determine the Tc in each subwatershed shall be clearly identified on the drainage area map. These shall correspond to the computations in the report and cannot extend beyond the watershed boundary.

   b. P_2=3.1 inches shall be used in the sheet flow travel time equation. Sheet flow length may not be more than 100 feet. Sheet flow lengths must be reasonable for ultimate conditions.

   c. The Manning's "n" factor for sheet flow shall reflect ultimate land use conditions.

   d. Computations shall be provided for determination of channel flow velocity. The velocity shall be taken from the hydraulic model output.

4. Rating Tables for Channel Routing (only to be used when significant effects on the 100-year Water Surface Elevation Level may be reasonably expected and with prior County approval):

   a. Rating tables for stage-discharge and stage-end area relationships shall be generated from non-proprietary hydraulic analysis such as HEC-RAS modeling. (Identify sections used).

   b. Rating tables shall be adjusted to reflect proposed channel conditions.

5. Rating Tables for Reservoir Routing (only to be used when significant effects on the 100-year Water Surface Elevation Level may be reasonably expected and with prior County approval):

   a. The most recent and updated topographic information shall be used to calculate stage-storage relationship. If two-foot contour maps are available, they must be used.

   b. Elevation interval between A1 and A2 shall not be greater than two feet when the following equation is used to estimate available storage:

      $S=(A1 + A2)/2 \text{ times } \Delta H$

   c. The flood elevation calculated from the TR-20 run and the predicted flood elevation calculated from the HEC-RAS run shall be within 0.5 foot of each other. The models must be adjusted until they correspond.

   d. Rating tables shall reflect the post construction channel conditions.

   e. In the event that a riser is proposed for a storm water management facility, the following procedures shall be used to determine the stage – discharge relations:

      1.) Compute, for each flow rate, the headwater elevation for the barrel pipe in inlet and outlet control conditions. Select the higher elevation as WSEL (h) <u>inside</u> the riser.

      2.) Assume a WSEL (H) <u>outside</u> the riser. Compute flow rates entering the riser at each opening using appropriate flow equations (weir or orifice flows). For weir flow conditions, if tailwater (h, determined at step "1") is above the weir crest then adjust the discharge for the submergence effect.

      3.) Add the computed flow rates entering the riser at each opening together to determine the total flow rate entering the riser (Q). Compare the incoming to outgoing flow rates. If different, assume a different WSEL (H) outside the riser and repeat steps 1 and 2.

6. Storm Events - The 24-hour rainfall amount for the 100-year storm event in Carroll County is 8.0 inches until changed by NOAA. Use rainfall distribution Type II and Antecedent Moisture Condition II.

7. TR-20 Standard Control:

   a. The input shall match the TR-20 schematic and drainage area map.

b. Reach lengths shall reflect the centerline stationing of the channel. Reach lengths used in the TR-20 shall match those shown on the drainage area and floodplain maps and used in the HEC-RAS runs.

c. Input data used in the TR-20 run must be consistent with the back-up calculations generated for:

Drainage Area
Runoff Curve Number
Time of Concentration
Rating Tables for both Channel & Reservoir Routings

d. Total drainage areas calculated by the TR-20 run shall match the mapped watershed drainage areas.

Sect. 4.5 Hydraulics

A. Applicability:

1. Where floodplain studies are performed in areas that meet the criteria of Section 4.1C.1.a, the requirements of Section 4.5.C may be greatly simplified.

2. Where floodplain studies are performed in areas that meet the criteria of Section 4.1.C.1.a, with prior County agreement, requirements of Section 4.5.C.1, .2, .3. and .4 may be simplified to a single profile with hydraulic cross-sections tied to it and water surface elevations (WSELs) computed through Manning's equation.

B. General Hydraulic Study Requirements:

1. Floodplain maps

a. Centerline stationing of channel with all hydraulic cross-sections and pre and post development hydraulic structures stationed along it. Cross-sections used to develop tailwater conditions on hydraulic structures must be shown. Equalities between the centerline stationing and hydraulic cross-sections, weir profiles, and any hydraulic structure stationing shall be shown.

b. Pre and post development water surface elevations (WSELs) shall be provided at each cross-section.

c. Hydraulic cross-sections shall be plotted with a zero point shown where each section begins and all Manning's coefficients shown between tic marks. The Manning's coefficients shall be stated at the first and last sections where they are used.

d. Pre and post development changes to the stream channel and floodplain shall be shown.

e. Survey control data, ties to traverse lines etc. in accordance with Section 5.

f. All existing and proposed buildings or building sites shown.

g. The 100-year flood flows used in the study shall be labeled on the first and last cross-section that they are applied to.

h. All ineffective flow areas shown.

2. Hydraulic Cross-Sections

a. Shall be oriented from left to right facing downstream.

b. Shall be plotted showing pre and post condition ground surfaces, WSELs, energy grade lines, and Manning's roughness coefficients.

3. Profiles

a. Shall be oriented to correspond to the floodplain map.

b. Shall be plotted showing pre and post condition ground surfaces, water surfaces, energy grade lines, and all hydraulic structures and cross-sections.

4. Hydraulic Structures (Pre and Post Development)

a. Structure geometry – opening sizes, shapes, lengths, and inlet and outlet inverts.

b. Materials, structure and roadway.

c. Channel protection.

d. Road (weir) centerline profile with survey control data.

e. Inlet / outlet control computations and rating tables.

f. Back up computations for input to the hydraulic model.

C. Specific Hydraulic Study Requirements:

1. Reach lengths shall reflect the centerline stationing of the channel. Reach lengths used in the TR-20 shall agree with those shown on the floodplain map and used in the HEC-RAS runs.

2. Loss Coefficients

a. Manning's "n" values shall reflect the standard approved Carroll

County design value unless different values and agree to by the County when revising an existing FEMA detailed study.

b. Proper expansion and contraction coefficients shall be used.

3. Hydraulic cross-sections shall be generated from field survey or at minimum from two-foot ariel topography. In critical areas, field surveys of the stream channel are required.

4. Starting Water Surface Elevation. Water surface elevations can be obtained from the following sources or whichever is the highest:

a. Most recently approved FEMA study (with approval from the County).

b. Previously approved 100-year floodplain maps. Contact Carroll County or FEMA to inquire about the availability and acceptability of a floodplain study. Any available previously approved maps may be viewed at County offices to determine adjacent floodplain conditions.

c. If a known WSEL is unavailable, the study shall be extended downstream to the nearest hydraulic structure (road, pond, etc.) that would have a backwater impact. As a last resort, the normal depth computations in the HEC-RAS boundary conditions should be used. When the normal depth method is utilized, the study shall be extended a minimum of 500 feet downstream of the site. If the computed WSEL is assumed to be critical depth, the appropriate information shall be entered into the HEC-RAS boundary condition data. The County reserves the right to direct that the study be extended to begin and end at structures.

5. Hydraulic Structure Modeling

a. Headwater elevation at bridges/culverts can be determined using the HEC-RAS bridge routines or by hand computations. Due to their flexibility in handling different flow regimes, we encourage the use of the HEC-RAS bridge routines. For complicated flow situations, the County reserves the right to require the used of the bridge routine. Independent confirmation using HY-8 or hand culvert analysis methods may be required. When using the bridge routines, the modeler should pay particular attention to the requirements in the HEC-RAS user manual.

b. Top-widths at upstream and downstream face of structures shall be reasonably encroached. For pressure or low flow conditions, the top width shall be the same as structure opening. For weir flow, the top width shall be limited to the overflow width. The calculated velocity head should not be more than 0.5 feet at the upstream face of structure.

c. More detailed evaluation is required to verify adequacy of critical depth at structure cross-sections. For low flow or pressure flow conditions, modeling shall reflect proper expansion of flow downstream of the structure and contraction of flow upstream of the structure.

d. If storage effects are considered the WSEL produced by the TR-20 must be within 0.5 feet of the energy grade elevation produced by the hydraulic model.

e. If headwater elevations are calculated using hand computations, the Federal Highway Administration pipe / culvert charts or HY-8 model shall be utilized. Tailwater shall be considered in analyzing outlet control. For low flow conditions, the hydraulic model bridge routine shall be used. The bridge routine is the preferred method to compute weir flow. If hand computations or the HY-8 model are used, explain all assumptions (determination of C, L, and H) and document references.

6. Super-critical flow conditions produce large velocity heads. Therefore, when a supercritical hydraulic model is produced, the 100-year floodplain delineations shall be based upon energy grade elevations.

7. If channel modifications are proposed, hydraulic models shall be prepared for both existing and proposed channel conditions. The models shall extend upstream until water surface elevations converge (preferably at a structure).

8. All notes and remarks in the hydraulic model output shall be reviewed. Any discrepancies shall be addressed, errors shall be corrected and warnings investigated, modified, and as a last resort, explained in the narrative. Super-critical flows are very rare in natural conditions and result in unreasonably low WSELs. For this reason, all such messages shall be adequately verified before the model will be accepted. At a minimum, this verification shall include:

a. Check coding of stream and cross-section data information.

b. Confirm location of bank stations to ensure that they reflect actual field conditions. Locating the bank stations unreasonably far apart will cause too much water to flow in the channel because of the lower Manning's "n" value.

c. Additional cross-sections may need to be inserted in order to preserve the assumption of gradually varied flow. Check top-widths at cross-sections for realistic transition of flow between cross-sections.

d. Sensitivity analysis for increasing Manning's "n" value for channel

and overbanks. Computer runs should be included in the submission package.

e. As a last resort, persistent message should be explained in the report.

SECTION 5 SUBMITTAL STANDARDS

A. Coordinates for all floodplain studies and plats shall be based upon the Maryland Coordinate System, North American Datum of 1983 / 99.

B. Elevations and topographic information shall be based on the North American Vertical Datum of 1988 (NAD 88).

C. Coordinate and elevation values shall be provided in feet.

D. At least four (4) north / east grid tics shall be provided on the floodplain plans and plats.

E. Prior to final plan approval a copy of the approved floodplain map shall be submitted to Carroll County in digital form. The floodplain map shall be submitted on a labeled CD-ROM in "Geographic Information System (G.I.S. Shapefile)" or CADD drawing file (.dgn). The County currently prefers "Geographic Information System (G.I.S. Shapefile)". These software requirements are subject to change as the industry standards evolve.

Appendix 1:

Manning's "n" values

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n (*continued*)

Type of channel and description	Minimum	Normal	Maximum
C. EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
D. NATURAL STREAMS			
D-1. Minor streams (top width at flood stage <100 ft)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

County Value

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n (*continued*)

Type of channel and description	Minimum	Normal	Maximum
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
D-2. Flood plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
D-3. Major streams (top width at flood stage >100 ft). The n value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	.....	0.060
b. Irregular and rough section	0.035	.....	0.100

County Value

Ven Te Chow "Open Channel Hydraulics", 1981, McGraw-Hill

Appendix 2:

Floodplain Policies

RE: **Revised Rainfall Depth Associated with the 100-year, 24-hour storm event**

Dear Surveyor/Engineer:

As per §114-5 of the Carroll County Code, the one hundred (100) year storm event is described as "a storm that has a 1% chance of being equaled or exceeded in any given year, as determined by the National Oceanographic and Atmospheric Administration and the National Weather Service."

On June 2, 2005, NOAA released final documentation of the attached Atlas 14, Volume 2, Version 2.1, which supercedes information contained in Technical Paper No. 40 "Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years" (Hershfield, 1961), NWS HYDRO-35 "Five- to 60-minute precipitation frequency for the eastern and central United States" (Frederick et al., 1977) and Technical Paper No. 49 "Two- to ten-day precipitation for return periods of 2 to 100 years in the contiguous United States" (Miller et al., 1964). The updates are based on more recent and extended data sets, currently accepted statistical approaches, and improved spatial interpolation and mapping techniques.

For all projects with an initial submittal date of May 1, 2006 or later, the newly published rainfall amount (8.0 inches) will be required in all 100- year floodplain computations. If you have any questions or require additional information, please do not hesitate to contact me at (410) 386-2321.

Sincerely,

Martin B. Covington, III, P.E., CFM
Stormwater Management Program Engineer

Distributed at Carroll County Surveyors' Meeting held on April 19, 2006

MBC/jts

Attachment

cc: Policy File

H:\Resource Management\Floodplain Management Letters\February 2006\NOAA Atlas 14, Volume 2, Version 2.1\NOAA Atlas 14, Volume 2, Version 2.1, Letter to Surveyors Dated 2-6-06.doc

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

WESTMINSTER POLICE BRK, MARYLAND (18-9440) 39.55 N 76.9867 W 807 feet

Pavement Precipitation Frequency Atlas of the United States," NOAA Atlas 14, Volume 2, Version 2
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2004

Created: Mon Apr 3 2006

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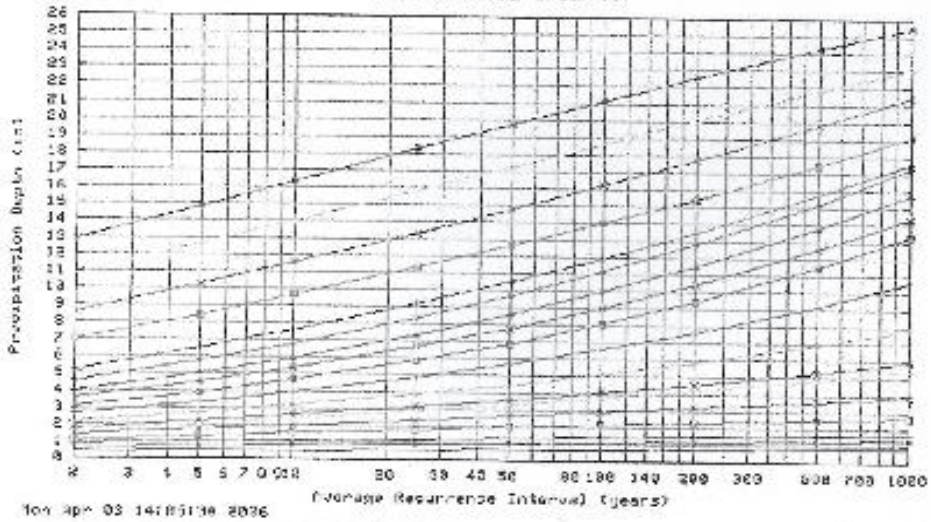
Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.40	0.64	0.80	1.11	1.39	1.63	1.76	2.16	2.62	3.05	3.53	3.94	4.57	5.21	7.01	8.60	10.79	12.85
5	0.47	0.76	0.95	1.35	1.74	2.07	2.23	2.73	3.33	3.91	4.53	5.02	5.77	6.50	8.46	10.22	12.59	14.84
10	0.53	0.84	1.06	1.53	2.00	2.41	2.60	3.20	3.94	4.67	5.38	5.96	6.80	7.58	9.64	11.52	14.00	16.55
25	0.59	0.94	1.19	1.77	2.35	2.90	3.14	3.90	4.86	5.84	6.65	7.37	8.34	9.15	11.29	13.32	15.85	18.80
50	0.64	1.02	1.29	1.94	2.63	3.31	3.58	4.50	5.68	6.88	7.78	8.60	9.67	10.47	12.83	14.76	17.26	19.76
100	0.69	1.09	1.38	2.11	2.91	3.75	4.05	5.15	6.60	8.06	9.03	9.97	11.14	11.91	14.02	16.24	18.65	21.17
200	0.73	1.16	1.47	2.28	3.19	4.21	4.57	5.87	7.62	9.40	10.42	11.49	12.78	13.47	15.47	17.76	20.02	22.52
500	0.79	1.25	1.58	2.50	3.58	4.85	5.30	6.94	9.20	11.46	12.54	13.80	15.22	15.73	17.49	19.84	21.81	24.26
1000	0.84	1.31	1.65	2.67	3.85	5.44	5.92	7.85	10.57	13.28	14.37	15.79	17.32	17.61	19.11	21.47	23.15	25.32

Text version of table

* These precipitation frequency estimates are based on partial duration series. ARI is Average Recurrence Interval.
Please visit Precipitation Frequency Publications for more information. NOAA Forecasting Focus estimates may not appear as zero.

Partial duration based Point Precipitation Frequency Estimates Version: 2
39.55 N 76.9867 W 807 ft



Mon Apr 03 14:05:38 2006

Duration
5-min
10-min
15-min
30-min
60-min
2-hr
3-hr
6-hr
12-hr
24-hr
18-hr
4-day
7-day
10-day
20-day
30-day
45-day
60-day