**KYTC Hydrologic and Hydraulic Software Recommendations**

**April 24, 2023**

The following list of hydrologic and hydraulic software is a summary of drainage software that has been commonly used and accepted by the Cabinet. This list is not intended to be comprehensive. Certain situations may require the need to use other industry standard drainage software not in this list. It is recommended that the drainage designer submit a request to the Drainage Branch for approval of drainage design software not in this list. The review will provide blanket approval, guidelines for its use and/or request additional information to determine its acceptability.

This list is intended to direct designers to applications appropriate for hydrology and hydraulic calculations and methods specified in the Drainage Manual.

**Hydrology – Rational Method**

**FHWA Hydraulic Toolbox**

Website: <https://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox404.cfm>

The FHWA hydraulic toolbox is a freeware application that includes a rational runoff method calculator. Within that module is a calculator that calculates time of concentration. The current version of the program will allow the user to reference a geographic location and access NOAA rainfall intensity values.

The program only allows for one typical channel section per drainage area, so the user must furnish a representative channel section to represent channel flow for the entire area.

 **KYTC Spreadsheet – Rational Method Calculations 17d – 04-14-2023**

Website: <https://transportation.ky.gov/Highway-Design/Pages/Drainage-Resource-Materials.aspx>

KYTC has developed a spreadsheet that perform the calculation of Rational Method flow rates. The user can specify either the SCS method (used in TR-55), or the ‘McCuen’ method (used in HEC-22) for calculating time of concentration.

It allows the user to specify up to 3 channels for the ‘Channel Flow’ portion of the time of concentration (Tc) calculation. It should be noted that this spreadsheet should NOT be used to perform channel shear analysis, and that the Manning’s ‘n’ should be specified by the user and should remain constant throughout the iterative process of calculating the Time of Concentration.

**InRoads Storm & Sanitary**

InRoads Storm & Sanitary is a Bentley product. It operates on the InRoads V8i and Power InRoads applications. InRoads Storm and Sanitary offers Rational runoff calculations using the Kinematic Wave Equation for overland flow, provided by HEC-22. The user must calculate the average velocity for the channel flow portion of the calculation (KYTC recommends using the Drainage Structure Analyzer to calculate this velocity). Please note that the calculations for the components of time of concentration are NOT saved with the individual drainage areas. To save this information, it must be reported out of the ‘Computer Time of Concentration’ interface.

The program is useful in graphically laying out drainage systems and showing the connectivity of the components within the system. The program is also able to determine the longest flow path between multiple drainage areas that are interconnected within a drainage system, allowing it to utilize the longest time of concentration for the entire drainage area. It should be noted that Bentley intends on phasing InRoads out in the next several years.

**OpenRoads Designer (ORD) Drainage**

ORD Drainage is also a Bentley Product. Hydrologically and hydraulically, it is set up similar to StormCAD, operating in the ORD platform. ORD Drainage allows for calculation of time of concentration utilizing various methods, including TR-55 and HEC-22 methodologies. Calculation of the channel flow component for Tc currently requires the user to provide an area and wetted perimeter for each individual channel, presumably for ‘full flow’ conditions. ORD Drainage saves the calculations used to determine time of concentration with each drainage area (known as a ‘catchment’).

As with InRoads S&S, the program can be used to graphically lay out drainage systems and show the connectivity of the components within the system. This program is also able to determine the longest flow path between multiple drainage areas.

**StormCAD**

StormCAD is a standalone Bentley product, operating similar to ORD Drainage. As with ORD Drainage, StormCAD allows for calculation of time of concentration utilizing various methods, including TR-55 and HEC-22 methodologies, determining the longest flow path for Tc, and saving the calculations used to determine time of concentration with each drainage area (catchment).

**WMS (Watershed Modeling System)**

Website: <http://www.ems-i.com/WMS/WMS_Overview/wms_overview.html>

WMS is a robust hydrologic application that can be used for many different watershed calculations. It performs all KYTC recommended calculations and can estimate many of the parameters from digital terrain data. It contains time of concentration calculation procedures that allow for rational peak flow calculations.

**Hydrology – Regional Method**

**USGS StreamStats**

Website: [StreamStats (usgs.gov)](https://streamstats.usgs.gov/ss/)

StreamStats provides access to spatial analytical tools that are useful for water-resources planning and management, and for engineering and design purposes. The map-based user interface can be used to delineate drainage areas, get basin characteristics, and estimates of flow statistics, and more. Modeling variables and output varies from state to state. The program utilizes the USGS’s Bulletin 17C – Guidelines for Determining Flood Flow Frequency (Regional Method) to provide peak flows for several return intervals. It should be noted that there are areas within the Commonwealth of Kentucky where StreamStats does not provide peak flow data.

**National Streamflow Statistics Program (NSS)**

Website: <https://water.usgs.gov/software/NSS/>

The NSS program is a freeware application that models all the flow regions in Kentucky (and the United States). Both rural and urban flows may be calculated. The regional equations and their various exponents and coefficients are programmed into the application. The user selects the region of interest from pull down menus and enters the required variable describing the physical characteristics of the watershed.

WMS models regional flows using NSS. (This ability is listed below under the Unit Hydrograph Method)

**WMS (Watershed Modeling System)**

Website: <http://www.ems-i.com/WMS/WMS_Overview/wms_overview.html>

WMS is a robust hydrologic application that can be used for many different watershed calculations. It performs all KYTC recommended calculations and can estimate many of the parameters from digital terrain data. It contains time of concentration calculation procedures as well as the newest USGS regional calculations. WMS models regional flows using the NSS application.

**KYTC Spreadsheet – Regional Method Calculations 1e3**

**Website:** [Drainage Resource Materials | KYTC](https://transportation.ky.gov/Highway-Design/Pages/Drainage-Resource-Materials.aspx)

This spreadsheet is based on the methodology is detailed in USGS Survey Water-Supply Paper 2207 (1983) titled “Flood Characteristics of Urban Watersheds in the United States”. The spreadsheet provides flows for various return events throughout the seven regions of Kentucky, and allows for urbanization, development, and gaged flow data.

Part of Jefferson County utilizes its own set of equations, and this spreadsheet allows for the use of these equations in areas where appropriate. Not all of Jefferson County is governed by this equation. The spreadsheet provides maps showing the delineation of the various regions, including the boundary designating use of the Jefferson County equations.

**Hydrology – Unit Hydrograph Method**

**OpenRoads Design (ORD) Drainage – SewerGems or CivilStorm**

Bentley offers additional software addons for ORD Drainage, including SewerGems and CivilStorm. Through these programs’ Implicit Dynamic or Explicit (SWMM) dynamic solvers, the user has the ability to model and route hydrographs through drainage networks.

**HEC-HMS**

**Website:** [HEC-HMS (army.mil)](https://www.hec.usace.army.mil/software/hec-hms/)

The Hydrologic Modeling System (HEC-HMS) is a free package supplied by the US Army Corps of Engineers, designed to simulate the complete hydrologic processes of dendritic watershed systems. The software includes many traditional hydrologic analysis procedures such as event infiltration, unit hydrographs, and hydrologic routing. The software features a completely integrated work environment including a database, data entry utilities, computation engine, and results reporting tools. A graphical user interface allows the user seamless movement between the different parts of the software. Simulation results are stored in HEC-DSS (Data Storage System) and can be used in conjunction with other software for studies of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, and systems operation.

**Win TR-55 & Win TR-20**

Website: <https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/water>

The Win TR-55 and Win TR-20 are freeware applications specifically designed by the NRCS to perform their unit hydrograph calculation procedures. Although the WIN TR-55 program will likely be capable of handling most hydrograph calculations required for a highway project, it does have some limitations. When these limitations are exceeded the Win TR-20 application should be used.

**InRoads Storm & Sanitary**

Another tool available with Bentley’s InRoads Storm & Sanitary is the ability to model runoff using NRCS unit hydrograph calculations (under the Pond Routing command). The TR-55 Graphical Peak Discharge option allows for the computation of peak discharge for up to three different storm events.

**WMS (Watershed Modeling System)**

Website: <http://www.ems-i.com/WMS/WMS_Overview/wms_overview.html>

WMS is a robust hydrologic application that can be used for many different watershed calculations. It performs all KYTC recommended calculations and can estimate many of the parameters from digital terrain data. It contains time of concentration calculation procedures as well as the newest USGS regional calculations.

The WMS software package also includes HY-8 and the FHWA Hydraulic Toolbox.

**HydroCAD**

HydroCAD is a Computer Aided Design tool that models both rational and NRCS Unit Hydrograph runoff. It allows for the entry of local rainfall data, provides easy management and reporting of multiple rainfall events, and provides a built-in CAD watershed import tool.

HydroCAD is ideal for studies using the TR-20, TR-55, or SBUH methods. HydroCAD provides a wide range of standard hydrology and hydraulics techniques in an easy-to-use graphical form, managed by an on-screen routing diagram.

**Precipitation Frequency Estimates**

**NOAA Precipitation Frequency Data Server (PFDS)**

Website: <https://hdsc.nws.noaa.gov/hdsc/pfds/>

The Precipitation Frequency Data Server (PFDS) is a point-and-click interface developed to deliver NOAA Atlas 14 precipitation frequency estimates and associated information. Upon clicking a state on the map above or selecting a state name from the drop-down menu, an interactive map of that state will be displayed. From there, a user can identify a location for which precipitation frequency estimates are needed.

Estimates and their confidence intervals can be displayed directly as tables or graphs via separate tabs. Links to supplementary information (such as ASCII grids of estimates, associated temporal distributions of heavy rainfall, time series data at observation sites, cartographic maps, etc.) can also be found.

Both rainfall intensity and total depth for specific return events can be derived from this website. Rainfall intensity data is commonly used to build intensity-duration-frequency (IDF) tables, while the total depth data can be used to provide a unit hydrograph.

**Culvert Design and Analysis**

**HY-8**

The HY-8 Culvert Hydraulic Analysis Program incorporates Hydraulic Design Series Number 5 (HDS-5), Hydraulic Design of Highway Culverts; Hydraulic Engineering Circular No. 14 (HEC-14), Hydraulic Design of Energy Dissipators for Culverts and Channels; and HEC-26, Culvert Design for Aquatic Organism Passage. Currently, KYTC **strongly recommends** the utilization of HY-8 in the comprehensive design of culverts.

Please note that while the design of several culvert outlet scour countermeasure are available in HY-8, it does not provide for the design of riprap aprons at the outlet of culverts. However, outlet scour information from HY-8 can be used in conjunction with the FHWA Hydraulic Toolbox to complete such a design.

HEC-RAS 1D and HEC-RAS 2D

Website: [HEC-RAS Downloads (army.mil)](https://www.hec.usace.army.mil/software/hec-ras/download.aspx)

HEC-RAS is a free software package supplied by the US Army Corps of Engineers for modeling steady and unsteady state flow. Pipes, box culverts and irregularly shaped geometries may be modeled.

**WMS (Watershed Modeling System)**

The WMS software package also includes the HY-8 program and can be used for culvert analysis.

**ORD Drainage**

While ORD Drainage offers headwater analysis for culverts, it currently does NOT offer the ability to define the road or high ground elevation that defines the location that weir flow begins occurring. For that reason, KYTC currently does NOT accept ORD Drainage culvert headwater analysis.

**Culvert Outlet Scour Countermeasure Design**

**FHWA Hydraulic Toolbox**

Website: <https://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox404.cfm>

The FHWA Toolbox provides a Riprap Analysis calculator. Within that calculator, the ‘Culvert Outlet Protection’ module (found within the ‘Structure Type’ pulldown) that allows for the design of riprap aprons. Data from the HY-8 scour module can be used to complete this design

**Storm Sewer Design and Analysis**

**ORD Drainage**

ORD Drainage offers storm sewer analysis utilizing HEC-22, Third Edition methodology. KYTC CADD Standards provide FlexTables that summarize:

* The ratio of flow depth to storm sewer pipe height for the design storm (10 year, or 25-year for inlets in a roadway sag).
* The HGL for the inlet and outlet ends of storm sewer pipes for the 100-year check storm.
* The HGL for inlets for the 100-year check storm, with inlet grate elevations to determine if the HGL will exceed the grate height.
* The HGL for manholes and junction boxes for the 100-year check storm, with manhole/junction box lid elevations to determine if the HGL will exceed the grate height.

**StormCAD**

StormCAD utilizes the same hydraulic model as ORD Drainage, utilizing HEC-22, Third Edition methodology. However, KYTC has not provided FlexTables to summarize results, which are still required as part of the drainage submittal.

**InRoads Storm and Sanitary**

InRoads Storm and Sanitary offers storm sewer analysis utilizing HEC-22, **Second** Edition methodology. including flow depth and hydraulic grade line (HGL) calculations. Flow Depth and HGL reports are available from KYTC upon request. This software is acceptable for older projects that predate KYTC implementation of ORD Drainage.

**Head on Grated Inlet Design and Analysis**

**KYTC Spreadsheet KYTC Grate HW for Inlets in Sag**

Website: <https://transportation.ky.gov/Highway-Design/Pages/Drainage-Resource-Materials.aspx>

KYTC offers a spreadsheet on the it’s Design webpage that calculates head on inlets for the 10-, 25- and 100-year flows. The spreadsheet determines the headwater depth on a sag grated inlet utilizing HEC-22 Equation 4-26 and 4-27 for weir and orifice flow. It also allows the user to specify a clogging factor on the grate (KYTC policy requires a clogging factor of 50%).

**Pavement Spread Design and Analysis**

**ORD Drainage**

ORD Drainage offers spread analysis utilizing HEC-22, Third Edition methodology. KYTC CADD Standards provide FlexTables that summarize data for the spread analysis.

**StormCAD**

StormCAD utilizes the same hydraulic model as ORD Drainage, utilizing HEC-22, Third Edition methodology. However, KYTC has not provided FlexTables to summarize results, which are still required as part of the drainage submittal.

**InRoads Storm and Sanitary**

InRoads Storm and Sanitary offers spread analysis utilizing HEC-22, **Second** Edition methodology. Spread analysis reports are available from KYTC upon request. This software is acceptable for older projects that predate KYTC implementation of ORD Drainage.

**KYTC Spreadsheet – Curb Box Inlet Calculations**

Website: <https://transportation.ky.gov/Highway-Design/Pages/Drainage-Resource-Materials.aspx>

This spreadsheet provides spread calculations for a variety of KYTC inlets. An unlimited number of inlets and systems may be modeled as described in the instructions.  Flow direction is assumed downward from the top of the spreadsheet. If a sag is indicated, flow direction is determined to direct flow to the collection point at the sag. By-pass flow is appropriately assigned. Refer to spreadsheet instructions.

**Channel Lining Design and Shear Analysis**

**KYTC Spreadsheet – KYTC Channel Lining Analysis Spreadsheet**

Website: <https://transportation.ky.gov/Highway-Design/Pages/Drainage-Resource-Materials.aspx>

This spreadsheet utilizes HEC-15 methodology to provide shear analysis for vegetative, rolled erosion control product (Turf Reinforcing Mats) and riprap channel linings. The channel linings are specific to the linings in KYTC’s Standard Specifications. This spreadsheet allows the analysis of up to 23 channel sections. In addition to determining the maximum shear and allowable shear on the maximum slope, it provides the flow depth on the minimum ditch slope for the design and check storms, as well as the lining quantity for the given section.

**FHWA Hydraulic Toolbox**

Website: <https://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox404.cfm>

The ‘Channel Lining Design Analysis’ calculator provides shear analysis for a variety of channel linings. In Specific data for the type and class of lining being evaluated must be entered by the user.

**Bridge Scour Analysis and Countermeasure Design**

**FHWA Toolbox**

Website: <https://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox404.cfm>

Within the FHWA Toolbox, the Bridge Scour Analysis Calculator utilizes information provided from HEC-RAS 1D, HEC-RAS 2D or SRH-2D, as well as soil data at the bridge to provide data on long term degradation, contraction scour, local scour at piers, and local scour at the abutments.

Countermeasure Design is found in the FHWA Toolbox’s Riprap Analysis calculator. Within the calculator pulldown, countermeasure design for piers and abutments/guide banks is provided.

**FEMA Floodplain/Floodway Analysis**

**HEC-RAS 1D/HEC-RAS 2D**

Website: [HEC-RAS Downloads (army.mil)](https://www.hec.usace.army.mil/software/hec-ras/download.aspx)

FEMA has indicated it will accept both one-dimensional and two-dimensional models for floodplain and floodway analysis. Existing HEC-2 and HEC-RAS models from previous flood studies may be imported for use in proposed studies.

**SRH-2D**

**Website:** [SMS Downloads | Aquaveo.com](https://www.aquaveo.com/downloads-sms?s=SMS&v=13.2)

SRH-2D is surface water modeling software produced by Aquaveo through an agreement with FHWA. It is provided free to government employees.

FEMA has also indicated it will accept SRH-2D analysis.

**Other**

**InRoads Storm & Sanitary**

A very useful tool in this program is the Drainage Structure Analyzer in the Evaluation pulldown, which allows the user to quickly check basic flow properties (spread, depth of flow, capacity) in a culvert, storm sewer, channel or gutter.