US Army Corps of Engineers®
Huntington District

Silver Jackets Special Study

South Licking, Ohio

Watershed Analysis

South Licking Silver Jackets – Raccoon Creek Logjam Model

HYDROLOGY AND HYDRAULICS APPENDIX

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HYDROLOGY AND HYDRAULICS APPENDIX
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Purpose

Logjams on the South Licking watershed are believed to have increased flooding due to blockages. The outcome of this analysis would facilitate prioritization of removal of logjams by order of risk. The analysis consisted of both hydrologic and hydraulic models. The goal of this effort is to provide an analysis of Raccoon Creek that will determine which logjam removals will provide the most beneficial flood reduction. The area of interest modeled was Raccoon Creek and one of its tributaries, Lobdell Creek.

Study Area

Raccoon Creek is a stream in the South Licking watershed in Licking County, Ohio. It is 83.6 mi^2 and is primarily used as agricultural land. The Village of Granville is the only incorporated area along the stream. Lobdell Creek is a larger tributary branching from Raccoon Creek that is 19 mi^2. Lobdell Creek is also primarily used for agricultural land use and the only incorporated area is the Village of Alexandria. Combined, Raccoon Creek and Lobdell Creek have 156 total blockages.

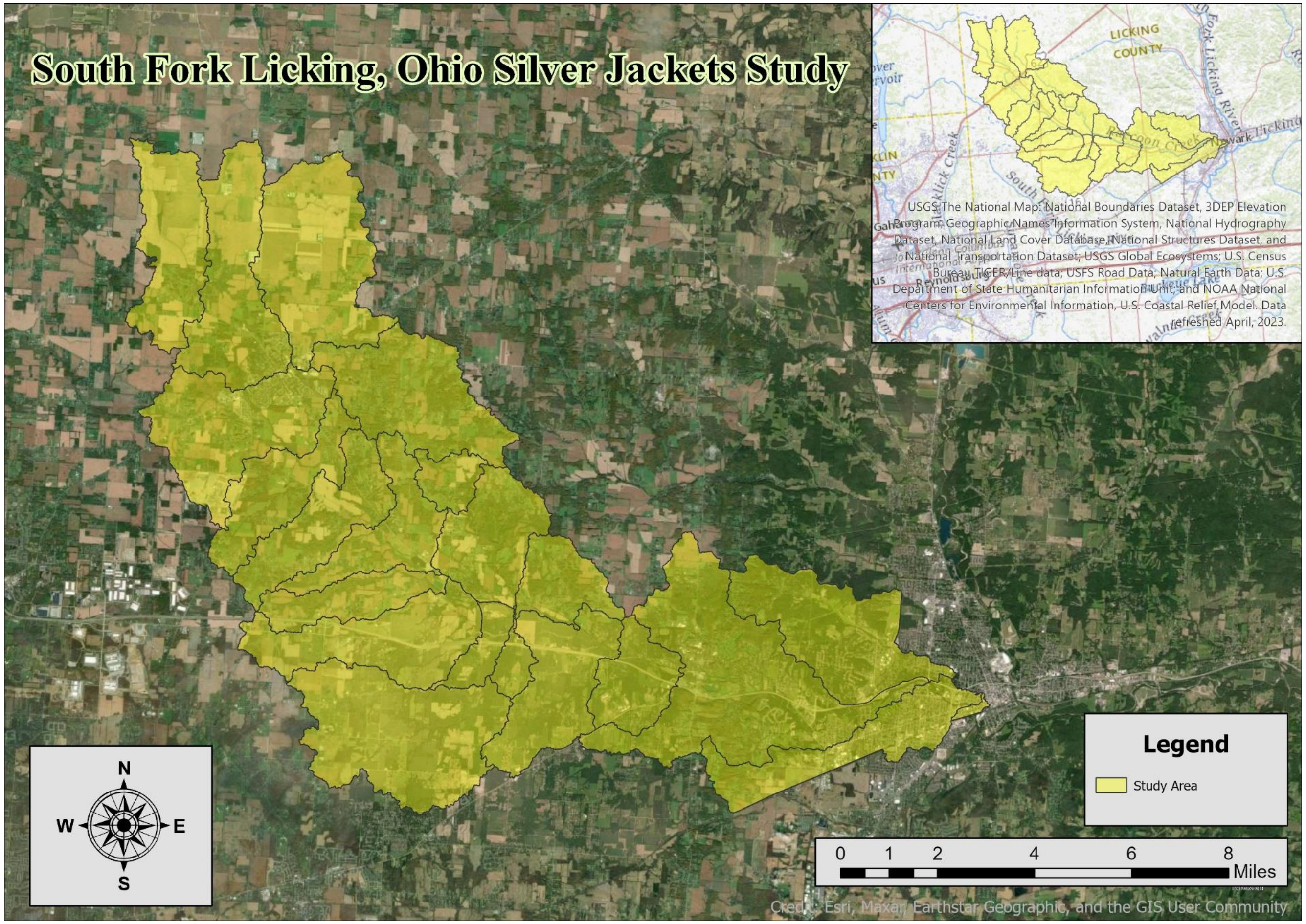

Figure 1 – Study Area

Modeling Methodology

The hydrologic and hydraulic modeling and analysis for this study was accomplished using models developed by the United States Army Corps of Engineers, Hydrologic Engineering Center (HEC). Peak discharges were determined using the Hydrologic Modeling System (HEC-HMS). Water surface elevations were calculated using the River Analysis System (HEC-RAS). ArcView, a desktop Geographical Information System (GIS) software package developed by the Environmental Systems Research Institute (ESRI) was used to prepare input data for use in the hydrologic and hydraulic models.

Huntington District has developed the following products for this study:

1. Study Report.
2. 1D HEC-RAS Model
3. HEC-HMS Hydrologic Model

Data Collection and Development

Aerial Surveys

Relatively recent (2021), high-definition LIDAR data for Licking County was available from the USGS website (TNM Download v2 (nationalmap.gov)). This LIDAR dataset was used to produce a "bare earth" digital elevation model (DEM) of the study area. All bare earth elevation values are referenced to the North American Vertical Datum of 1988 (NAVD88). Horizontal projection data utilizes the NAD 1983 Albers Equal Conic.

Field Surveys

None were completed at this stage in the study.

National Land Cover Data

The National Land Cover Database 2019 was obtained from the Multi-Resolution Land Characteristics Consortium website (Data | Multi-Resolution Land Characteristics (MRLC) Consortium).

High Water Marks

High water marks were gathered from the National Oceanic and Atmospheric Administration (NOAA).

Hydrologic Model Development

Hydrologic Model (HEC-HMS)

A newly constructed HEC-HMS model for the Raccoon Creek Watershed was created according to the following steps:

- Collected relevant geographic and terrain data that could be found. Terrain data was developed from available lidar data for Licking County, Ohio. Downloaded ESRI GRID DEM Mosaic for Licking County from Ohio Geographically Referenced Information Program (OGRIP) on October 5, 2022. Terrain data was developed from available 1-meter lidar data from the USGS. The DEM was resampled to be 10-meter resolution, which is sufficient for HEC-HMS.

- Sub-basins were delineated by using the stream network and a 10-meter terrain model in HEC-HMS Version 4.10. The sub-watersheds were delineated at USGS 03145534 Raccoon Cr. bl. Wilson Street at Newark and OH USGS 03145483 Raccoon Creek near Granville OH, and at points close to where major logjams were located. The logjam locations came from the South Fork Licking River Watershed Land Use Evaluation and Woody Debris Mapping 2020 Report prepared by the Licking County Soil and Water Conservation District.

- Using the tools contained in HEC-HMS and the DEM, delineated the subbasins and determined the Basin Slope and time of concentration. Subbasins and reaches were named automatically based on hydrologic order.

- The version of HMS does not require a grid cell data layer, although version 4.10 allows the use of structural discretization. This is where a cartesian grid within the bounds of the subbasins is created on the fly. The HMS model was created using the NAD_1983_Albers projection. The Standard Hydrologic Grid (SHG) using a 2000-meter grid size was used for this model. This model is within the Huntington Districts Kanawha Watershed Corp Water Management System (CWMS) model geographic area which also uses the same projection and SHG in daily model run operations. The precipitation grid sets generated for the Muskingum Basin model could then be used to run various events that link gridded precipitation data to each sub-watershed and the parameters generated to propagate runoff would be imported into the HMS model for major events could be properly routed through the basins and the resulting flows at key gage locations could be used to calibrate the watersheds against observed flows. (**Error! Reference source not found.** illustrates the study watershed and sub-watersheds with the Standard Hydrologic Grid superimposed over the watershed)

- Once the HEC-HMS basin model would run based parameters for the Deficit and Constant loss method, Modified Clark transform, and Recession baseflow were refined. General sections were cut through the reaches and assigned to each reach for the Lag routing method.

- Historical data for precipitation was generated using the District's Muskingum CWMS model for major flood events. Data for the observed flows at the gages was downloaded through DSS Viewer 3.2.3 from the USGS websites using the UTC time stamp to correspond to the Precipitation data which also utilizes the UTC time system.

Hydrologic Soil Groups. The Hydrologic Soils Group (HSG) is a way of classifying soils as to their relative ability to generate runoff. It is a parameter that is required to estimate runoff using the CN Method. The method uses a letter designation A, B, C, D, or W to indicate a particular class. Class A soils have the highest permeability and lowest runoff potential, Class B is the next lowest, and Class C is lower than A and B. Class D has the lowest permeability and therefore has the highest runoff potential. Class W is used for open water bodies. Digital soil data was obtained for the state of Ohio from the Soil Survey Geographic (SSURGO) database. Specific soil types were classified as to their hydrologic group (A, B, C, D, or W), incorporated into a GIS layer, and attached to the watershed map.

Land Use and Land Cover. Land use and land cover are parameters that are also used in the CN Method. Each of these parameters is an indicator of the ability of the ground cover of an area (or sub-watershed) to produce runoff. Land use and land cover types with significant amounts of impervious area produce more runoff than types with little impervious area. Digital land use/land cover data was collected from the National Land Cover Database as developed by the Multi-Resolution Land Characteristics Consortium (MRLC). The latest dataset is from 2019.

Time of Concentration Method. The time of concentration is another key parameter necessary in hydrologic routings. The transform method used the ModClark Model. Much like the Clark Unit Hydrograph Model, runoff computations with the ModClark model explicitly account for translation and storage. Storage is accounted for with the same linear reservoir model incorporated in the Clark model. Translation is accounted for with a grid-based travel-time model. With the ModClark method, a grid is superimposed on the watershed. The distance to the watershed outlet is specified for each cell of the grid representation of the watershed (HEC, 2022). Times of concentration were calculated using HEC-HMS which is a group of extensions developed by the Hydrologic Engineering Center (HEC) of the United States Army Corps of Engineers. Times of concentration were based on the TR-55 methodology (USDA-Technical, Release 55, June 1986, Urban Hydrology for Small Watersheds). The estimated parameter used in the model was taken to be directly related to the longest flow path in the watershed (mi), centroidal flow path (mi), and slope of the flow path represented by 10 to 85 percent of the longest flow path (ft/mi). Each parameter was derived from the Study DEM.

Recession Baseflow Method. The recession baseflow method includes a recession constant for specifying the rate at which recession flow decreases with time. In HEC-HMS the parameter is defined as the ratio of the current recession flow to the recession flow one day earlier.

Lag Routing Method. This is the simplest of the included routing models. With it, the outflow hydrograph is simply the inflow hydrograph, but with all ordinates translated (lagged in time) by a specified duration. The flows are not attenuated, so the shape is not changed. This model is widely used, especially in urban drainage channels (Pilgrim and Cordery, 1993). Lag was estimated in the modeling space assuming 6 fps velocity and each segmented routing reach length.

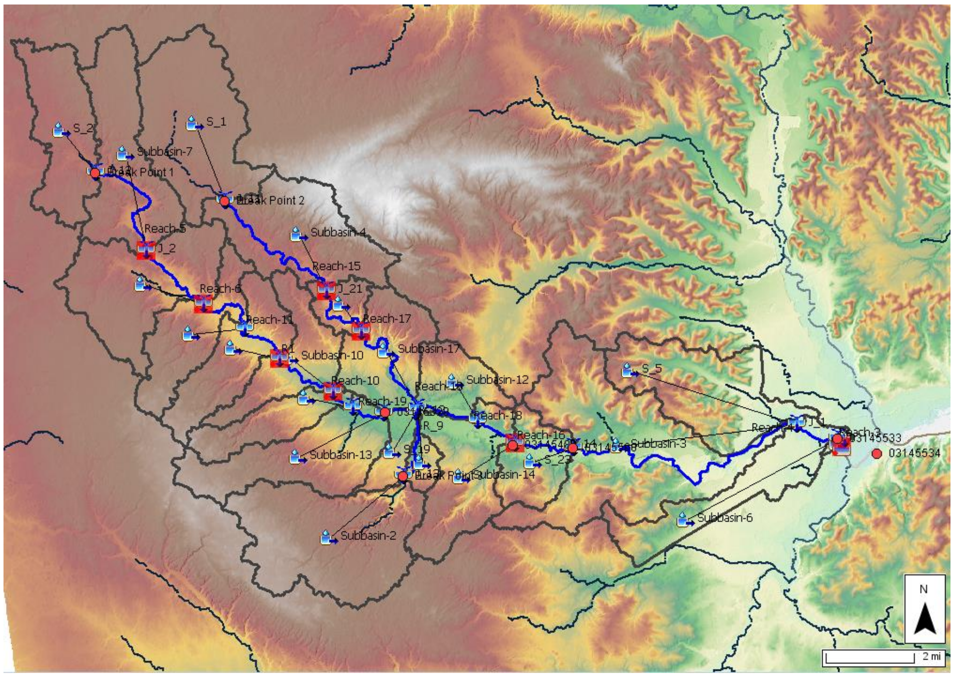

Figure 2 – Hydrologic Engineering Center – Hydrologic Modeling System Raccoon Creek, South Licking River, Ohio Watershed Schematic

The reason for using a hydrologic model is to simulate the response of the Raccoon Creek Watershed to rainfall and to develop peak flow estimates for use in the hydraulic model. Setting up a HEC-HMS model requires developing appropriate rainfall events, dividing the watershed into sub-watersheds, estimating hydrologic characteristics, and evaluating the storage and routing coefficients of the natural system. The methodology used to determine the watershed response or runoff from a rainfall event is the ModClark Transform Method and the Recession Baseflow Method.

HEC-HMS Initial Model Calibration

Hydrologic Model Calibration and Verification. Calibration is the process by which hydrologic parameters within the model are adjusted to gain confidence in the modeled results. One of the more acceptable approaches to calibrate a hydrologic model is to compare modeled results to observed stream gage records. Storm events of interest were determined by georeferencing photos of flooding provided by project partners and examining gage data for complete good quality data. When looking for quality data, data with no interpolation and no missing segments was preferred. Six storm events were identified, and gridded rainfall was collected for each event from the National Weather Service.

Calibration Events

- Mar 2020 18-22
- Feb 2022 16-20
- May 2020 18-23
- May 2021 8-11
- May 2022 3-10
- Jun 2022 12-17

Events from 2019 to 2022 were used to capture recent logjams more accurately.

Flood Seasonality and Mechanism

Raccoon Creek had seasonal flooding in February to June which were used to choose calibration events. Using seasonal flood events provided consistent parameters for validations at the same time of year (Figure 4).

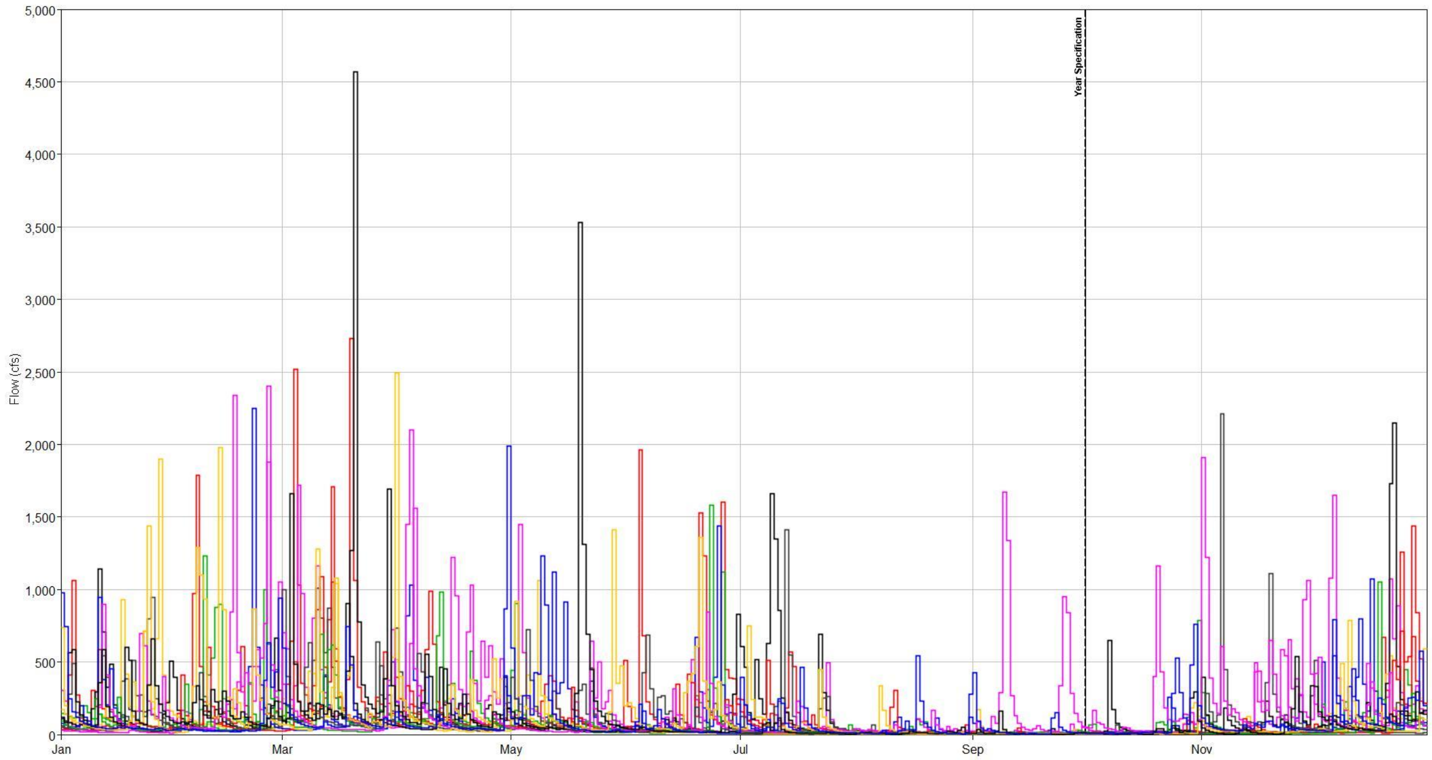

Figure 3 – Raccoon Creek Flood Seasonality

Gages

There are five gages along Raccoon Creek, two active gages with 15-minute data were used for our observed data in calibrating the HMS model, USGS 03145534 Raccoon Cr. bl. Wilson Street at Newark and OH USGS 03145483 Raccoon Creek near Granville OH. Both active and inactive gages were considered when gathering data. Three other gages were along Raccoon Creek but could not be pulled for Gages with only field measurements include: USGS 03145329 Raccoon Creek at Alexandria OH and USGS 03145533 Raccoon Creek at Newark OH. One gage contained historical data from the 1940s only, USGS 03145500 Raccoon Creek at Granville OH.

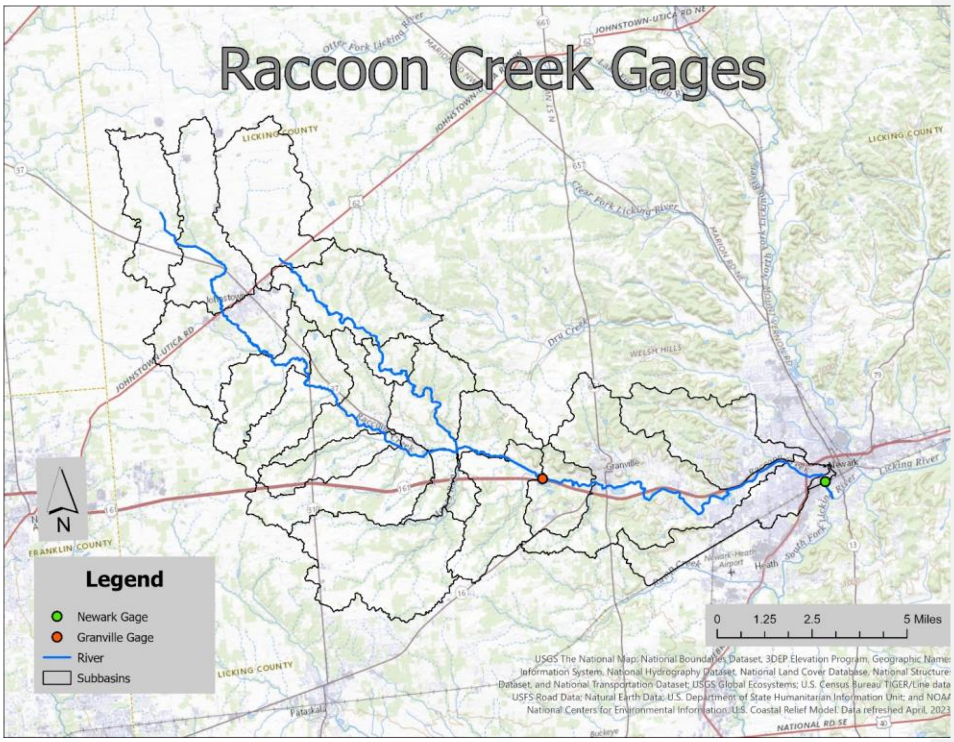

Figure 4 – Raccoon Creek Gage Locations

Hydrologic Calibration

Calibration is the process by which the parameters within the model are adjusted to gain confidence in the model's results. The best way to calibrate a hydrologic model is to compare model results with stream gage records. There are two USGS gages that report real-time 15-minute data within the study watershed. The locations of these gages and the contributing areas to these gages can be seen in Figure 4. The gage locations are Raccoon Creek below Wilson Street at Newark Ohio and Raccoon Creek near Granville Ohio. This is real-time rain data that is located utilizing 2000-meter grids. The Huntington District runs the Muskingum Watershed's Corp Water Management System (CWMS) model daily. This real-time rain data is propagated through the HMS model. The initial losses, constant losses, Mod Clark R-values, Time of Concentration (TOC) as well as "n" values for reaches were adjusted as closely as possible to match the real-time results at the gages. The model was calibrated utilizing computation points at real-time gages. This would eliminate any calibration errors for areas that are already gaged upstream. This allowed the areas after Granville to be calibrated independently.

Hydrologic Model Validation

Upon completion of the six calibrations, the parameters for the calibrations were averaged. The averaged parameters were applied to two validation events March 2020 and February 2019.

Table 1 – Nash Sutcliffe and Percent Bias at Gages March 2020 Calibration

March 2020 Calibrated		
Gage	Nash Sutcliffe	Percent Bias
Granville	0.934	16.01
Newark	0.921	-6.73

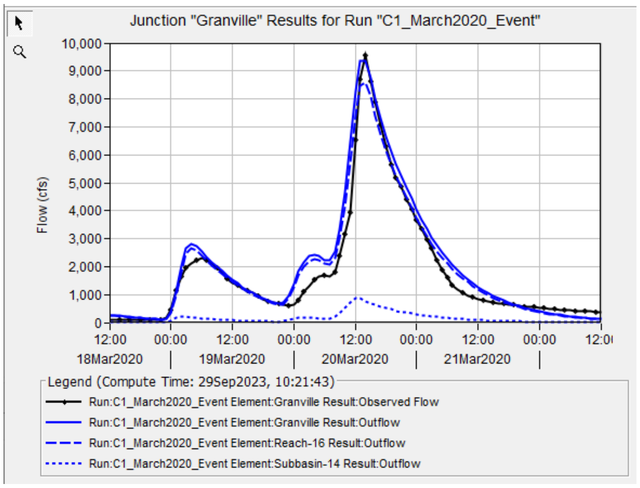

Figure 5 – March 2020 Calibration at Granville Gage

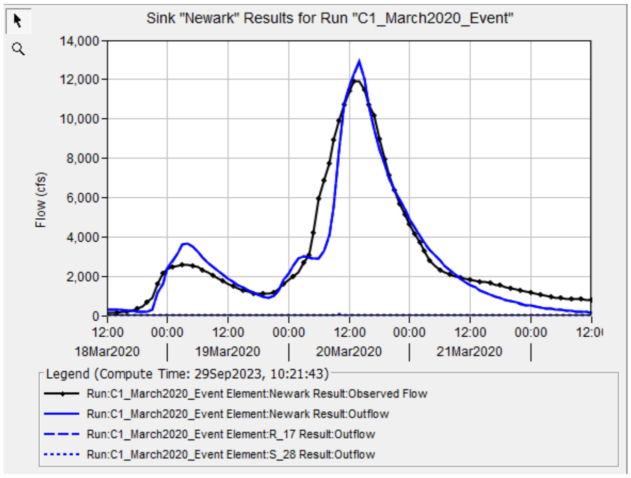

Figure 6 – March 2020 Calibration at Newark Gage

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Table 2– Nash Sutcliffe and Percent Bias at Gages May 2020 Calibration

May 2020 Calibrated		
Gage	Nash Sutcliffe	Percent Bias
Granville	0.972	-0.25
Newark	0.878	-9.69

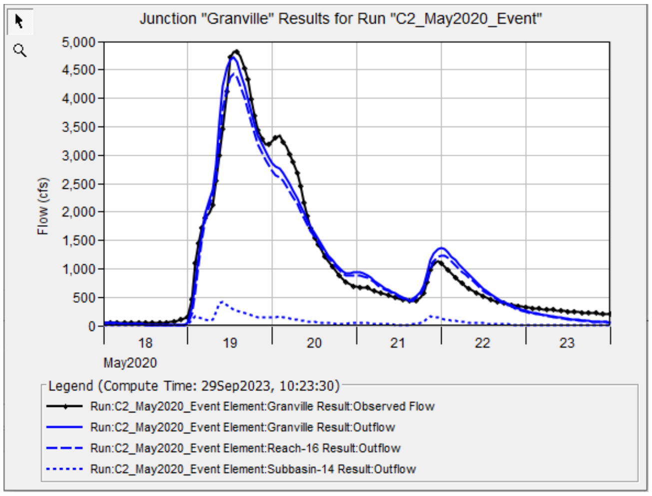

Figure 7 – May 2020 Calibration at Granville Gage

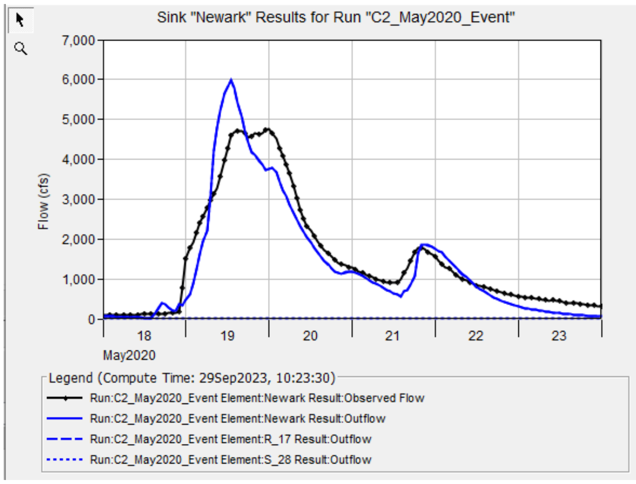

Figure 8 – May 2020 Calibration at Newark Gage

Table 3 – Nash Sutcliffe and Percent Bias at Gages May 2021 Calibration

May 2021 Calibrated		
Gage	Nash Sutcliffe	Percent Bias
Granville	0.935	-5.37
Newark	0.77	-7.53

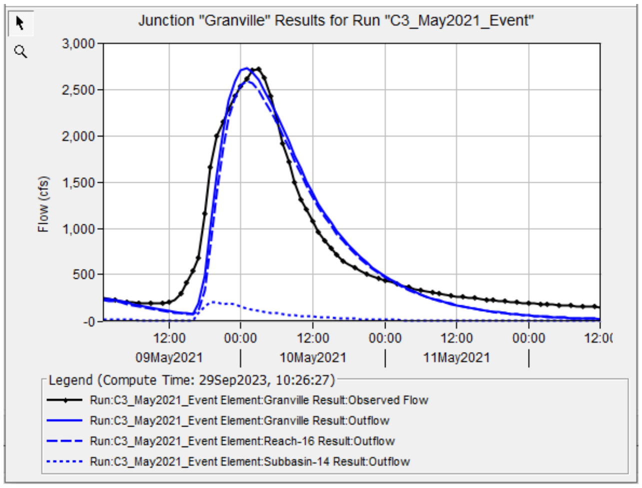

Figure 9 – May 2021 Calibration at Granville Gage

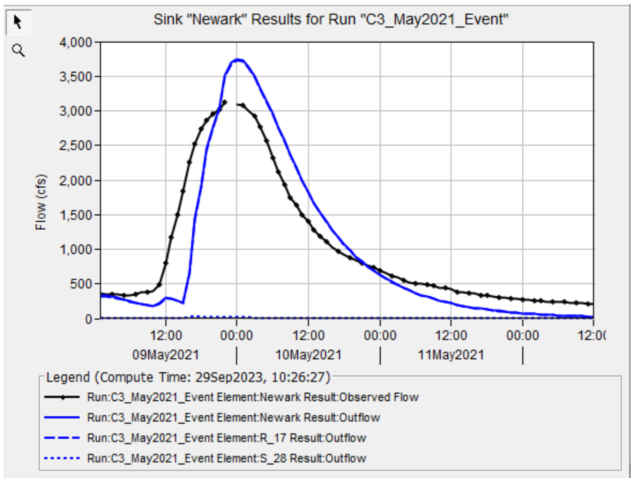

Figure 10 – May 2021 Calibration at Newark Gage

Table 4 – Nash Sutcliffe and Percent Bias at Gages February 2022 Calibration

February 2022 Calibrated		
Gage	Nash Sutcliffe	Percent Bias
Granville	0.961	-5.96
Newark	0.815	-7.9

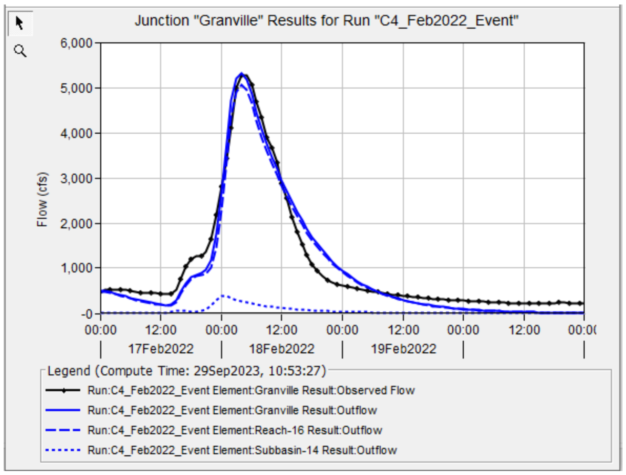

Figure 11 – February 2022 Calibration at Granville

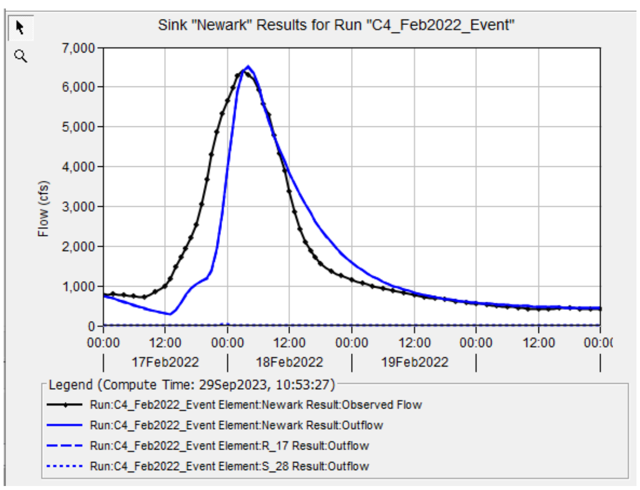

Figure 12 – February 2022 Calibration at Newark

Table 5 – Nash Sutcliffe and Percent Bias at Gages May 2022 Calibration

May 2022 Calibrated		
Gage	Nash Sutcliffe	Percent Bias
Granville	0.85	21.28
Newark	0.749	2.66

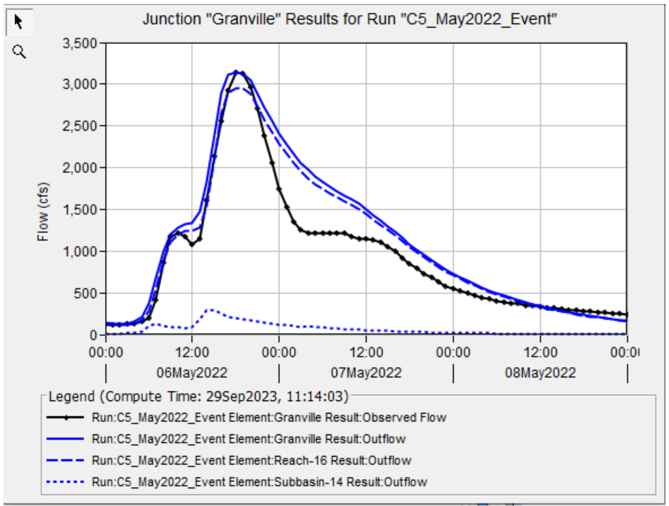

Figure 13 – May 2022 Calibration at Granville

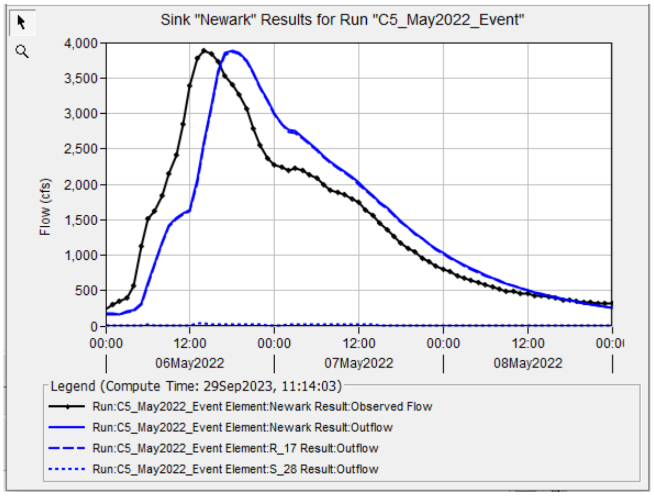

Figure 14 – May 2022 Calibration at Newark

Table 6 – Nash Sutcliffe and Percent Bias at Gages June 2022 Calibration

June 2022 Calibrated		
Gage	Nash Sutcliffe	Percent Bias
nville	0.959	11.48
wark	0.695	14.53

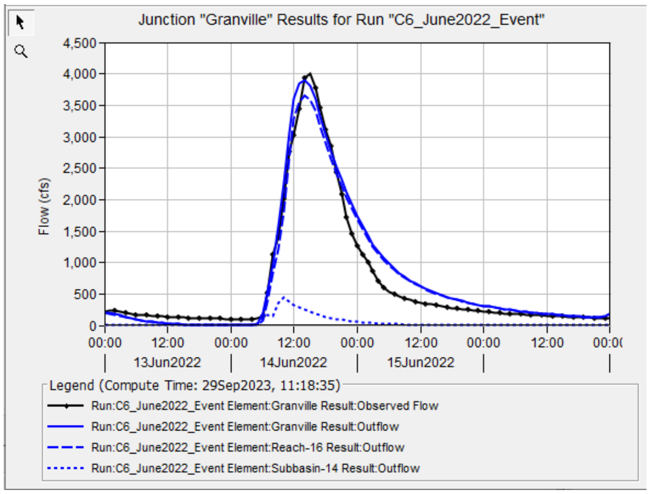

Figure 15 – June 2022 Calibration at Granville

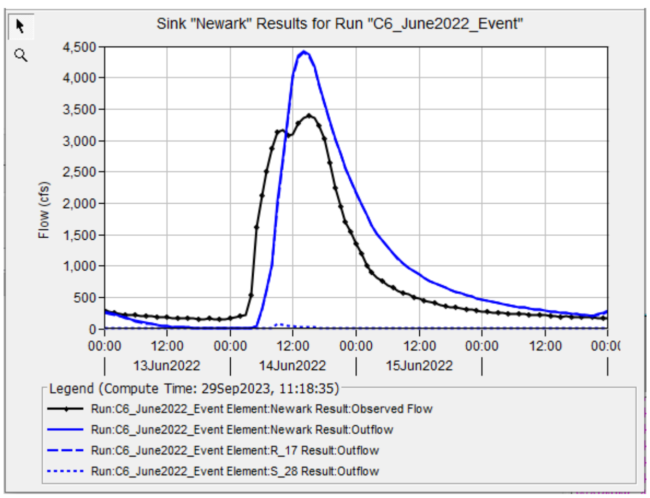

Figure 16 – June 2022 Calibration at Newark

Table 7 – Nash Sutcliffe and Percent Bias at Gages March 2020 Validation

March 2020 Validated		
Gage	Nash Sutcliffe	Percent Bias
Granville	0.903	6.74
Newark	0.832	-12.82

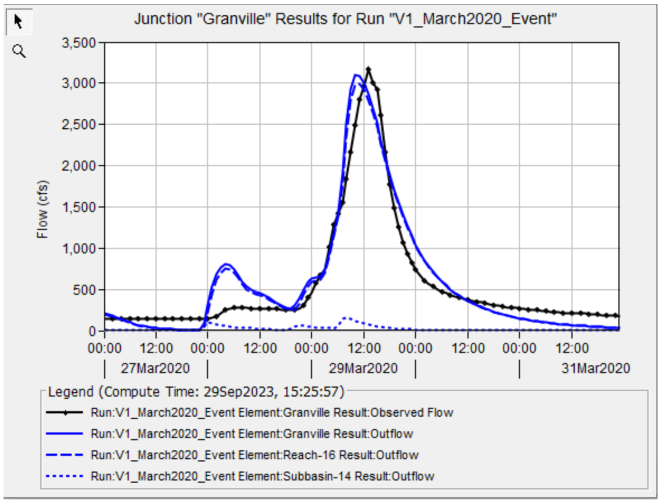

Figure 17 – March 2020 Validation at Granville

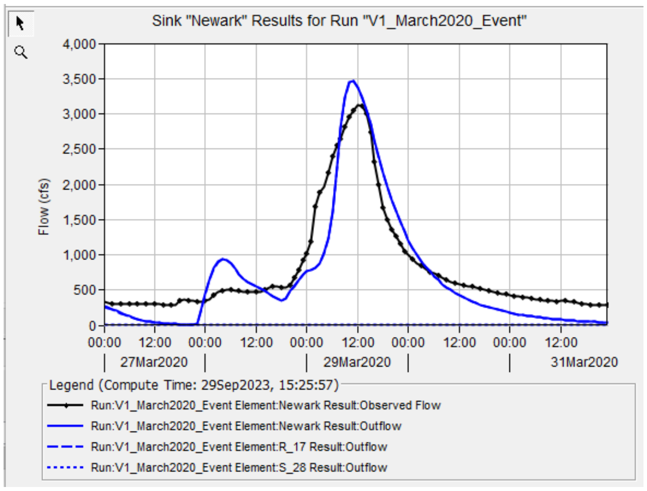

Figure 18 – March 2020 Validation at Newark

Table 8 – Nash Sutcliffe and Percent Bias at Gages February 2019 Validation

Feburary 2019 Validated		
Gage	Nash Sutcliffe	Percent Bias
Granville	0.909	-4.49
Newark	0.879	-20.61

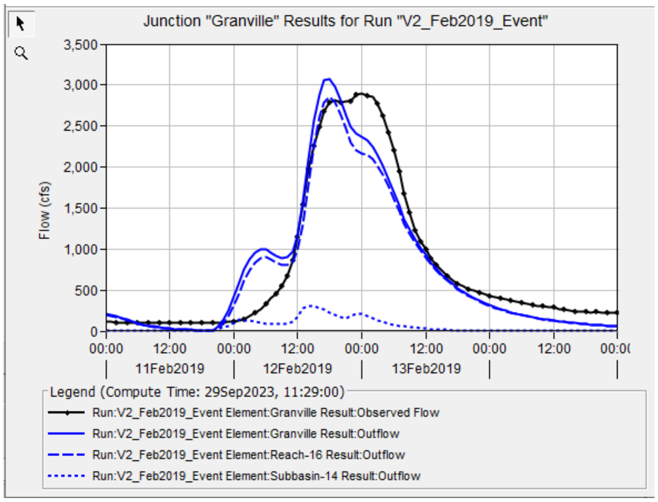

Figure 19 – February 2019 Validation at Granville

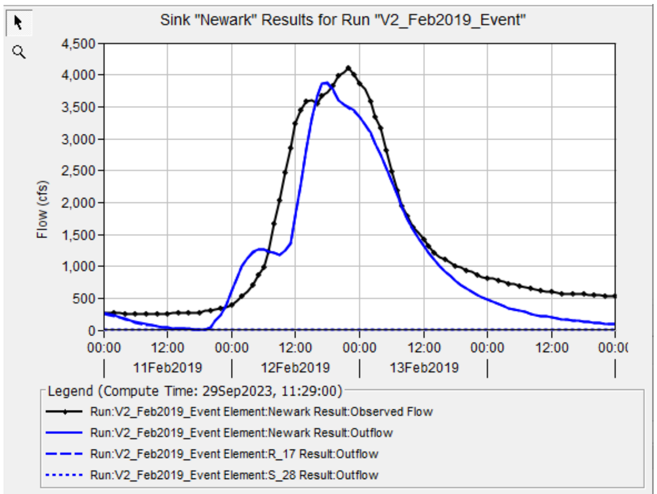

Figure 20 – February 2019 Validation at Granville

Hydraulic Model Development

Software:
HEC-RAS 6.3.1 (official release-September 2022) was used for this modeling effort.

Horizontal / Vertical Projection:
NAD 1983 2011 State Plane Ohio South FIPS 3402 Ft US

North American Vertical Datum (NAVD-88)

USA Contiguous Albers Equal Area Conic USGS version GCS North American 1983

Terrain:
One terrain Digital Elevation Models (DEM) dataset was used to cover model extents. Downloaded ESRI GRID DEM Mosaic for Licking County from Ohio Geographically Referenced Information Program (OGRIP) on October 5, 2022.

Geometry:
HEC-RAS Geometry Source(s)

Project partners provided supplemental models of the area. River center line and cross sections were used from the model "Raccoon Creek – USGS Alexandria to Thornwood Crossing Model." All other models provided had no data or were modeled outside of the study area. Each geometry component for the Raccoon Creek model was created in HEC-RAS mapper. The geometry components created include a stream center line, bank stations, flow paths, cross sections, lateral structures, and storage areas.

Moots Run

Originally, Moots Run, a lower tributary of Raccoon Creek was going to be modeled with its own geometry. However, when evaluating the complexity of the confluence it was determined that there would be few benefits for individually evaluating Moots Run. There are five logjams along the stream, however, all structures along Moots Run are on high ground and likely not affected by flooding. The land in this area is primarily farm use and there are few densely populated areas. Therefore, the stream was changed to a storage area to reduce complexity and prioritize the most impactful log jams.

Cross Sections

Each model cross-section was cut from 10-meter resolution LiDAR terrain and extended to neighboring watersheds that were delineated in HEC-HMS. Cross-section length was determined by creating a 2D mesh around the watershed area, and then running a 500-year flood event through the model. Cross sections were drawn to cover the extent of flooding. Cross sections from neighboring reaches are connected with a lateral flow boundary represented as lateral structures. Each lateral structure connecting cross sections was given a weir coefficient of 0.2 to represent a non-elevated overbank.

Manning's N values

Manning's N Values were adjusted for model stability and determined using the HEC-RAS manual and Roughness Characteristics of Natural Channels by the US Geological Survey

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Water Supply Paper 1849. Pictures of logjams and Raccoon Creek provided by project partners were used to visually estimate manning's n values for stretches of the creek. The final n-values for channels were 0.037 and overbanks were 0.095. The Flood Insurance Study for Licking County had a range of 0.045 to 0.075 for the channel and 0.01 to 0.115 for the overbanks. The channel value was slightly lower than the FIS recommendation, this decision was based on model stability and pictures from the area. Manning's n values were adjusted based on calibration and validations.

<u>Bathymetry</u>
Bathymetry came from the Ohio Licking County Flood Insurance Study streambed profiles. The streambed profiles were digitized and then used to create a linear interpolation. River stationing was input into the linear interpolation Excel sheet with fixed elevation being output. Fixed elevation was used to create a channel in cross sections and a template channel was used to standardize the channel shape. Lobdell Creek did not have any bathymetry from the Flood Insurance Study.

<u>Hydraulic Structures</u>
In the 1D model of Raccoon Creek, hydraulic structures from previous modeling provided by EMH&T engineering were used. The bridge structures were transferred using techniques from HEC-RAS 1D modeling training. Corresponding piers, sloping abutments, and ineffective flow areas were also transferred according to this training. Skew was applied to bridges when structures were not perpendicular to the river.

<u>Storage Areas</u>
There are eight storage areas in the HEC-RAS geometry, one of which is Moot's Run tributary. Storage areas use an elevation volume rating curve based on terrain.

<u>Ineffective Flow Areas</u>
Ineffective flow areas were set according to HEC-RAS manual guidance. Bridges had ineffective flow points on the two upstream and downstream bounding cross sections. These points were placed with a 1:1 upstream contraction and 1:4 compression ratio to accurately show the constriction around the bridge. The elevation of the upstream ineffective flow areas was the lowest elevation of the bridge's high cord. The downstream ineffective flow area elevations were determined by running the model and then adjusting the elevations to allow even flow across the bridge.

HEC-RAS Simulation Runs:
The model consisted of an unsteady 1D area. Discharge values found in Licking County, Ohio, and incorporated areas from the Flood Insurance Study "Table 8: Summary of Discharges".

<u>Boundary Conditions</u>
Flow hydrograph boundary conditions taken from HEC-HMS were placed at the beginning of each reach. Lateral inflow hydrographs were added based on sub-basin routings and assigned to appropriate cross sections.

Computational Window and Timestep

A 30 second computation interval was used with 1 hour mapping output, hydrograph output, and detailed output intervals. The simulation time windows captured the peaks of the validation or calibration event. The duration was typically five days.

Calibration and Validation

Calibration and validation events from HEC-HMS were used as storm events. Events were calibrated in HEC-RAS to observed data by reducing minimum flows and assigning appropriate Manning's N values.

Categorizing Blockages:

The Licking County Soil and Water Conservation District created South Fork Licking River Watershed Land Use Evaluation and Woody Debris Mapping 2020 which was used as the basis for ranking blockages. Woody debris was mapped using aerial imagery dated March 2019 from the Licking County Auditor. The imagery was taken when water levels were high and flooding in surrounding fields was evident. Debris was categorized as follows:

- Fallen Tree - one single tree
- Small - more than one tree/ multiple pieces of debris
- Large - pile of debris overtaking half of the width of the stream
- Very Large - pile of debris overtaking the majority of the width of the stream
- Total Blockage - the stream has begun to reroute itself around the blockage

Blockage locations were used to input logjams into the model in an attempt to recreate the blockage (Figure 21).

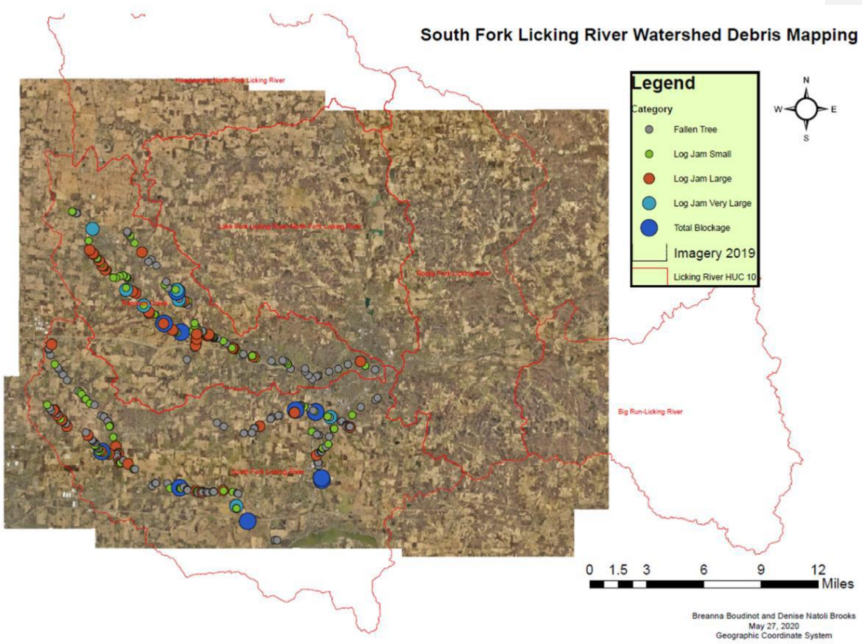

Figure 21 – South Fork Licking Watershed Debris Mapping

Table 9 – Summary of Debris throughout the South Fork Licking River Watershed

	Lobdell Creek	Raccoon Creek	Ramp Creek	South Fork	Muddy Fork	Unnamed Tributary	TOTAL by size
Fallen Tree	17	49	24	99	24	17	230
Log Jam Small	10	50	3	27	15	2	107
Log Jam Large	2	20	3	14	8	3	50
Log Jam Very Large	2	3	1	1	0	0	7
Total Blockage	1	2	3	4	1	0	11
TOTAL by river	32	124	34	145	48	22	405

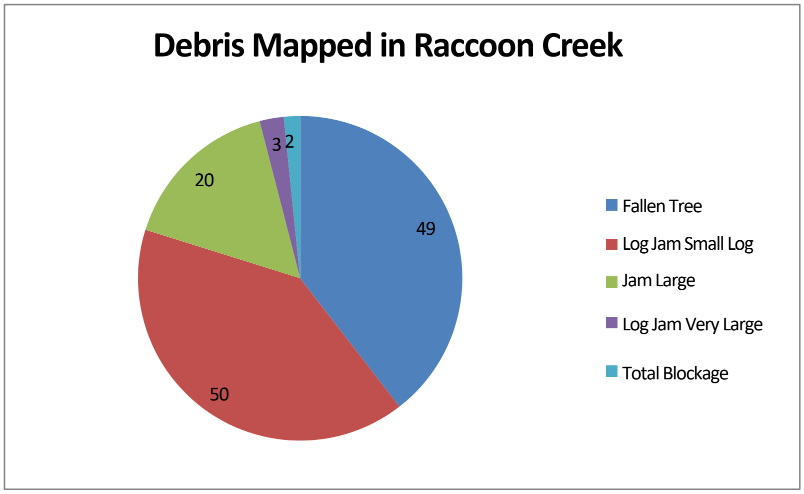

Figure 22 – Debris Mapped in Raccoon Creek

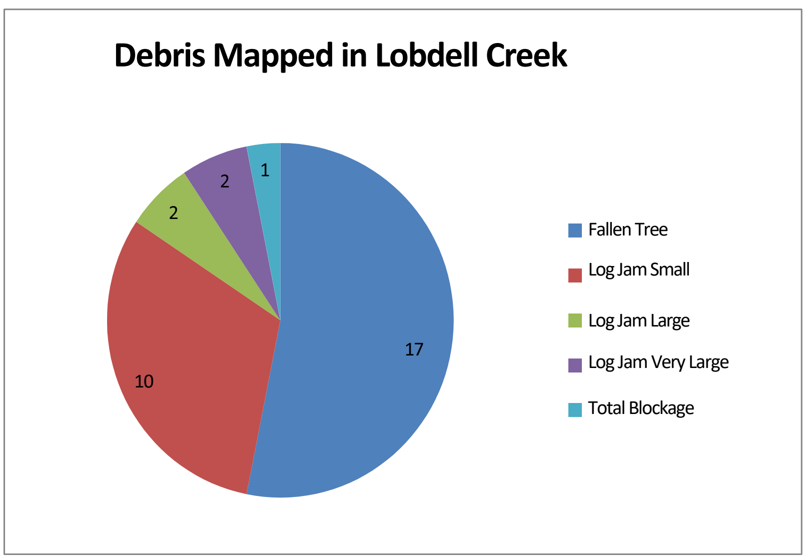

Figure 23 – Debris Mapped in Lobdell Creek

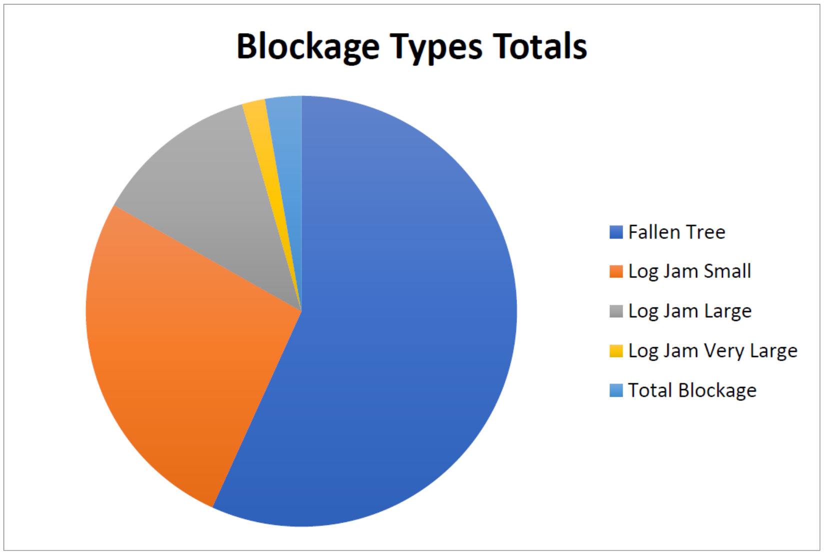

Figure 24 – Blockage Types Totals

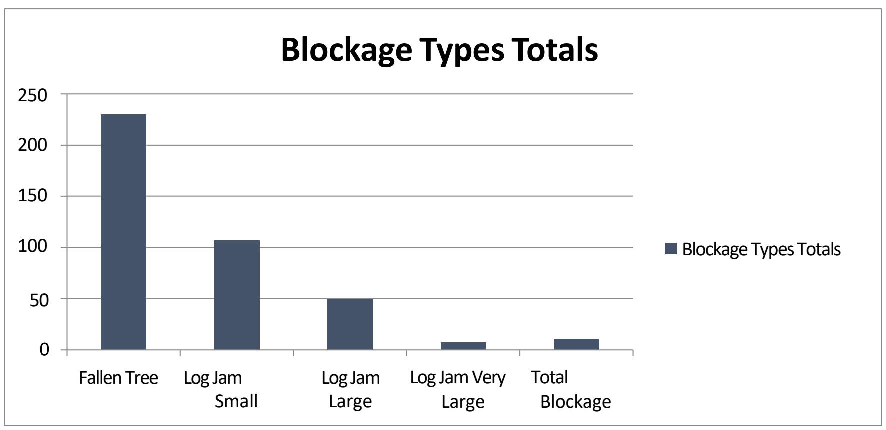

Figure 25 – Blockage Types Totals

Modeling Logjams:

All logjams were modeled with bridge structures and followed the logjam modeling methods in Table 10. Logjams were grouped based on approximate locations. Logjams close together were modeled as a group represented as the largest logjam or multiple smaller features in one

Commented [ARBCUC(6]: What table are you referring to? Because Table 1 talks about calibration of an event not the logjam modeling methods.

Commented [CCMC(7R6]: Table 10, fixed.

Commented [ARBCUC(8R6]: Comment Closed.

bridge structure. For example, Eight fallen trees as eight 0.5 wide piers with one bridge deck. 25 logjam groupings were used. Lone fallen trees and small logjams were excluded because they were likely low impact on water surface elevation.

Commented [ARBCUC(9]: Maybe use the word eight instead of the number.

Commented [CCMC(10R9]: Agreed, changed to eight.

Commented [ARBCUC(11R9]: Comment Closed.

Table 10 - Logjam Modeling Methods

Total Blockage	Total blockage with 1x1 culvert
Very Large Logjam	Total blockage with 2x2 culvert.
Large Logjam	Total blockage with 5x5 culvert
Small Logjam	1.0 wide pier with deck and floating debris 100x6
Fallen Tree	0.5 wide pier with deck and floating debris 100x3

Logjam Analysis:

To perform the analysis, one logjam group would be placed in a new geometry and run with validation 1, March 2020, flow boundary conditions. Logjams were ranked from least impactful to most impactful based on the change in water surface elevation between validation 1 with no logjams and the new logjam run. Inundation of buildings or structures was used as an additional factor for impact. Only one run inundated structures, one of which was a football field. This logjam was ranked most impactful because of its proximity to structures. More impactful logjams did not inundate buildings but had a significant increase in water surface elevation with the logjam in place. Less impactful logjams had no impact on structures and had minimal water surface elevation change. The least impactful logjams had no impacts on structures and had very little to no increase in water surface elevation. These results can be seen in Table 11 and Figure 26.

Table 11 – Logjam Analysis

Affecting Buildings	Change in WSE	River	Geometry	River Station	Number of Logjams	Fallen Trees	Small	Large	Very Large	Total Blockage	Modeling Method
no	Significant reduction in WSE.	North Tributary	Logjam_2	13529	1	0	0	1	0	0	Total blockage with culvert 2x2
no	Significant reduction in WSE.	North Tributary	Logjam_6	16350	1	0	0	0	1	0	Total blockage with culvert 2x2
no	Minor reduction in WSE above logjam.	North Tributary	Logjam_5	19940	1	0	0	0	0	1	Total blockage with culvert 1x1
no	Significant reduction in WSE.	North Tributary	Logjam_4	20450	1	0	0	0	1	0	Total blockage with culvert 2x2
no	No change in WSE	North Tributary	Logjam_15	43797	2	0	1	1	0	0	Total blockage with culvert 10x2
yes	Significant reduction in WSE.	RaccoonCrk_1	Logjam_11	5503	1	0	0	0	1	0	Total blockage with culvert 2x2
no	Significant reduction in WSE.	RaccoonCrk_1	Logjam_12	9778	1	0	0	1	0	0	Total blockage with culvert 5x5
no	Significant reduction in WSE.	RaccoonCrk_1	Logjam_13	10831	1	0	0	0	0	1	Total blockage with culvert 1x1
no	Significant reduction in WSE.	RaccoonCrk_1	Logjam_14	16443	2	1	0	0	0	1	Total blockage with culvert 1x1
no	Significant reduction in WSE.	RaccoonCrk_1	Logjam_26	50405	1	0	0	1	0	0	Total blockage with 5x5 culvert
no	Minor reduction in WSE above logjam.	RaccoonCrk_1	Logjam_25	53511	1	0	0	0	1	0	Total blockage with culvert 2x2
no	Significant reduction in WSE.	RaccoonCrk_1	Logjam_24	58232	3	1	1	1	0	0	Total blockage with culvert 4.5x4.5
no	Significant reduction in WSE.	RaccoonCrk_1	Logjam_23	58791	2	0	1	1	0	0	Total blockage with culvert 4.5x4.5
no	Significant reduction in WSE.	RaccoonCrk_1	Logjam_22	65076	8	8	0	0	0	0	8 piers 0.5w 3 floating debris
no	No change in WSE	RaccoonCrk_1	Logjam_21	67216	3	0	0	3	0	0	Total blockage with culvert 1x1
no	Minor reduction in WSE above logjam.	Reach 1	Logjam_3	76206	1	0	0	0	0	1	Total blockage with culvert 1x1
no	Significant reduction in WSE.	Reach 1	Logjam_9	82713	2	0	0	1	0	1	Total blockage with culvert 0.5x0.5
no	Significant reduction in WSE.	Reach 1	Logjam_8	92317	3	1	1	0	1	0	Total blockage with two 1x1 culverts
no	No change in WSE	Reach 1	Logjam_7	100325	1	0	0	0	1	0	Total blockage with culvert 2x2
no	No change in WSE	Reach 1	Logjam_20	122221	1	0	0	0	1	0	Total blockage with culvert 2x2
no	No change in WSE	Reach 1	Logjam_19	123411	1	0	0	1	0	0	Total blockage with culvert 10x2.5
no	No change in WSE	Reach 1	Logjam_18	123737	1	0	0	0	1	0	Total blockage with culvert 2x2
no	No change in WSE	Reach 1	Logjam_17	125162	1	0	0	1	0	0	Total blockage with culvert 10x2.5
no	No change in WSE	Reach 1	Logjam_16	128668	2	0	0	0	1	1	Total bockage with culvert 0.5x0.5
no	Minor reduction in WSE above logjam.	Reach 1	Logjam_10	134585	1	0	0	0	1	0	Total blockage with culvert 2x2

Legend
Most Impactful
More Impactful
Less Impactful
Least Impactful

Commented [ARBCUC(12]: Add this Table to a Landscape page so its easier to read.

Commented [CCMC(13R12]: Changed to landscape

Commented [ARBCUC(14R12]: Comment Closed.

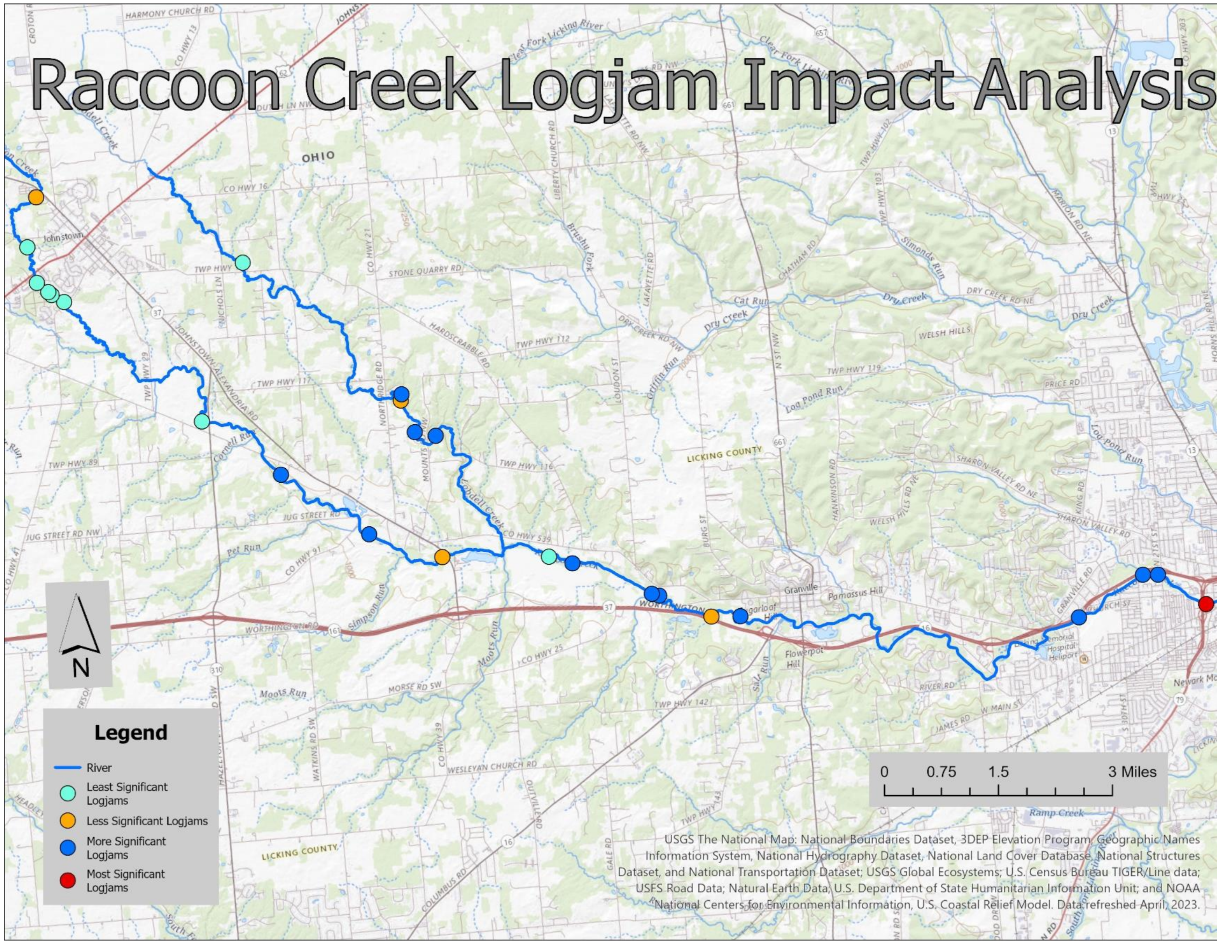

Figure 26 – Raccoon Creek Logjam Impact Analysis Results

Conclusions / Recommendations

Hydrologic Modeling Recommendations

Summary

The hydrologic HEC-HMS model developed for this assessment provides results that are considered to be highly uncertain for the South Fork Licking watershed. The primary function of the hydraulic HEC-RAS model developed for this assessment is to determine which logjams would provide the most benefit to the watershed both in terms of flood reduction and structure impact. Each logjam is simulated using a 1D unsteady model. Like the hydrologic model, accuracy through model calibration is paramount to achieve appropriate results, namely water surface elevations.

Commented [ARBCUC(15]: I think you are trying to say 1D unsteady model

Commented [CCMC(16R15]: Agreed, changed to 1D.

Commented [ARBCUC(17R15]: Comment Closed.

It is recommended that logjams with the most impact be prioritized for removal first to reduce flood damages.

Data

The accuracy of hydrologic parameters was validated through 6 calibration events and 2 validation events. High water marks were not available for this effort. It is recommended that permanent locations for high water marks be installed, and high-water marks recorded during flood events. This would facilitate a better understanding of the water surface elevations during flooding events. High water marks would also increase model accuracy and improve calibrations.

Specific logjam sizes and pictures with clear locations would also improve model estimates. Because of the broad categorization of logjams, the modeling for them had to be developed broadly. This is a source of uncertainty, as the true blockage of the logjams is unknown. The accuracy of the model would be improved if logjams were surveyed or photographed with locations.

References

Brooks, B. B. (2020). *South Fork Licking River Watershed Land Use Evaluation and Woody Debris Mapping.* Licking County Soil and Water Conservation District.

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