AR Highway 33 near Bisco, AR - Jocelyn Augustino/FEMA Photo by Jocelyn Augustino

Cache Watershed, AR Base Level Engineering (BLE) Results

Cache Watershed, HUC - 08020302

Clay*, Craighead*, Cross*, Greene*, Jackson*, Lawrence*, Monroe*, Poinsett*, Prairie*, Randolph*, St. Francis*, Woodruff* Counties, Arkansas and Butler* County, Missouri

**Spans more than one watershed. This report covers only the area within the studied watershed.*

June 2017

Project Area Community List

Community Name	CID
Clay County Communities	
Clay County[1]	050423
Knobel, City of	050032
McDougal, City of	050033
Peach Orchard, City of	050034
Piggott, City of[1]	050035
Pollard, City of	050036
Craighead County Communities	
Bono, City of	050046
Cash, Town of	050396
Craighead County[1]	050427
Egypt, Town of	050585
Jonesboro, City of[1]	050048
Cross County Communities	
Cross County[1]	050056
Greene County Communities	
Greene County[1]	050435
Lafe, Town of	N/A
Jackson County Communities	
Amagon, Town of	050097
Beedeville, Town of	050098B
Grubbs, City of	050101
Jackson County[1]	050096
Newport, City of[1]	050103
Tupelo, Town of	050106
Weldon, Town of	N/A
Lawrence County Communities	
Lawrence County[1]	050443
Sedgwick, Town of	050576
Walnut Ridge, City of[1]	050122
Monroe County Communities	
Brinkley, City of[1]	050155
Fargo, Town of	05X020
Monroe County[1]	050154
Poinsett County Communities	
Fisher, City of[1]	N/A
Poinsett County[1]	050172
Waldenburg, Town of[1]	050497
Weiner, City of[1]	050373

[1] Community is located within more than one HUC8 watershed.

Community Name	CID
Prairie County Communities	
Biscoe, City of[1]	N/A
Prairie County[1]	050459
Randolph County Communities	
O'Kean, Town of	N/A
Randolph County[1]	050460
St. Francis County Communities	
St. Francis County[1]	050184
Woodruff County Communities	
Cotton Plant, City of	050231
Hunter, Town of	
McCrory, City of	050232
Patterson, City of	050274
Woodruff County[1]	050468
Butler County Communities	
Quilin, City of	230048
Butler, County of	290044
[1] Community is located within more than one HUC8 watershed.	

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1. Executive Summary

The U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA) is currently implementing the Risk Mapping, Assessment, and Planning (Risk MAP) Program across the Nation. The vision and intent of the Risk MAP program is to, through collaboration with State and Local entities, deliver quality data that increases public awareness and leads to mitigation actions that reduce risk to life and property. To achieve this vision, FEMA has transformed its traditional flood identification and mapping efforts into a more integrated process of more accurately identifying, assessing, communicating, planning and mitigating flood risks. Risk MAP attempts to address gaps in flood hazard data and form a solid foundation for risk assessment, floodplain management, and provide State and Local entities with information needed to mitigate flood related risks.

The FEMA Region 6 office and the Arkansas Natural Resources Commission (ANRC) entered into a Cooperating Technical Partners (CTP) partnership agreement for implementation of Risk MAP in the State of Arkansas. As part of this partnership, the ANRC and its contractor, FTN Associates, Ltd. (FTN), began work on a Base Level Engineering (BLE) analysis in the Cache Watershed in October 2016 to support FEMA's Discovery process and validation of effective Zone A Special Flood Hazard Area (SFHA).

The BLE process involves using best available data and incorporating automated techniques with existing hydrologic and hydraulic (H&H) model development procedures to produce quality flood hazard boundaries and secondary products (Water Surface Elevation grids, Depth grids, etc.) for multiple recurrence intervals. The purpose and intent of the BLE process is to validate existing Zone A flood boundaries within the existing Coordinate Needs Management Strategy (CNMS) dataset and provide updated flood risk data in the early stages of a Flood Risk Project (Discovery). An important goal of the BLE process developed by FEMA is the scalability of the results. Scalability means that the results of an BLE cannot only be used for CNMS evaluations of Zone A studies but also leveraged throughout the Risk MAP program.

The source digital terrain data used for surface model development in support of H&H analysis, as well as mapping activities were leveraged from existing Light Detection and Ranging (LIDAR) data collected by the Federal Emergency Management Agency (2011 Cache and 2011 L'Anguille), U.S. Geological Survey (2011 Bayou Meto, 2012 Upper Black, 2012 Upper White Village, 2013 Lower St. Francis, and 2015 Lower Black), and the U.S. Army Corps of Engineers (2010 White River to Newport, 2010 Greers Ferry and Red River, 2014 AR-MO LIDAR Project). The LiDAR datasets were 1-meter gridded DEM data that were reprojected to a 15 ft cell size for hydrologic processing and a 5 ft cell size for hydraulic and mapping processing.

Flood discharges for this analysis were calculated using the National Oceanic and Atmospheric Administration's National Weather Service, Precipitation Frequency Data Server (PFDS) for Atlas 14, ESRI's ArcGIS software, the HEC-Hydrologic Modeling System (HEC-HMS) computer program, and the HEC - River Analysis System (HEC-RAS) program, version 5.0.3. Initial precipitation values were obtained, based on a watershed level, from NOAA's Precipitation Frequency Data Server (PFDS) for Atlas 14, which was then processed in ESRI's ArcGIS 10.x software into a usable format. The obtained preceipitation values and resulting GIS parameters for the watershed, were then input into HEC-HMS to determine the excess rainfall that would result based on the applied conditions. This excess rainfall was then applied to a 2-D HEC-RAS model in the form of a rain on grid scenario, which was then used compute the water surface elevations for the 10-, 4-, 2-, 1-, 0.2-percent-events and the 1-percent-minus and 1-percent plus flood events.

The modeled stream mile network for the Cache Watershed was compiled initially using FEMA's CNMS inventory. It was then expanded to include streams that extended upstream to a contributing drainage area of approximately 1 sq. mile.

2. Base Level Engineering (BLE) Methodology

This section provides guidance for the hydrologic, hydraulic and floodplain mapping steps required to create a BLE. The BLE process involves using best available data and incorporating automated techniques with existing H&H model development procedures to produce quality flood hazard boundaries and secondary products (Water Surface Elevation grids, Depth grids, etc.) for multiple recurrence intervals. The purpose and intent of the BLE process is to validate existing Zone A flood boundaries within the existing CNMS dataset and provide updated flood risk data in the early stages of a Flood Risk Project (Discovery).

The cost and effort for developing the data and estimates resulting from the BLE process are lower than standard flood production tasks. An important goal of the BLE process developed by FEMA is the scalability of the results. Scalability means that the results of an BLE cannot only be used for CNMS evaluations of Zone A studies but also leveraged throughout the Risk MAP program. The large volume of data resulting from an BLE can be used for the eventual production of regulatory and non-regulatory products, outreach and risk communication and MT-1 processing. Leveraging this data outside the Risk MAP program may also be valuable to external stakeholders.

Per the the Code of Federal Regulations, once every five years, FEMA must evaluate whether the information on Flood Insurance Rate Maps (FIRMs) reflects the current risks. This evaluation is done by examining the existing flood boundaries for changes in study attributes and physical characteristics, as specified in the CNMS Technical Reference. Additionally, this evaluation occurs using a series of critical and secondary checks to determine the validity of the existing flood hazard areas. In addition to the need for evaluating the accuracy of Zone A mapping, newer FEMA standards also require that flood risk data be provided in the early stages of a Flood Risk Project. Particularly, FEMA Program Standard SID #29 requires that during Discovery, data must be identified that illustrates potential changes in flood elevation and mapping that may result from the proposed project scope. If available data does not clearly illustrate the likely changes, an analysis is required that estimates the likely changes. This data and any associated analyses should be shared and results should be discussed with stakeholders.

Therefore, based on these requirements, the results of the BLE process are being provided to the local Floodplain Administrators (FPAs), which allows for users to have access to a model backed Zone A study that is suitable to replace the effective Zone A products. The following sections are being supplied to document the hydrologic, hydraulic, and floodplain mapping techniques used. Regardless of the individual techniques used to perform these steps, the goal of a scalable product should be adhered to throughout the entire BLE process.

2.1. Terrain

To determine the parameters for the hydrologic and hydraulic analyses, FTN obtained Digital Elevation Model (DEM) data developed from LIDAR information that was collected by the Federal Emergency Management Agency (2011 Cache and 2011 L'Anguille), U.S. Geological Survey (2011 Bayou Meto, 2012 Upper Black, 2012 Upper White Village, 2013 Lower St. Francis, and 2015 Lower Black), and the U.S. Army Corps of Engineers (2010 White River to Newport, 2010 Greers Ferry and Red River, 2014 AR-MO LIDAR Project). The bare earth DEM data was provided as 1-meter or 1/3 arc-second DEMs with varying horizontal and vertical coordinate systems. Prior to use, the DEM data was reprojected to a 15 ft cell size for hydrologic processing and a 5 ft cell size for hydraulic and mapping processing with a horizontal coordinate system of NAD 1983 State Plane Arkansas North (feet) and a vertical datum of NAVD 88 (feet). DEMs were then mosaicked into a single DEM that covered the entire watershed. The single DEM was then processed using Environmental Systems Research Institute's (ESRI) ArcMap Geographic Information System (GIS) 10.x software and the ArcHydro toolset to develop the hydrologic parameters needed for use in the hydrologic modeling.

A terrain and workmap index has been prepared and is attached to the end of this report and included in Appendix A – Workmaps.

2.2. Hydrology

Excess runoff for the 10-, 4-, 2-, 1-, 0.2-percent-events and the 1-percent-minus and 1-percent plus flood events were calculated using NOAA's Precipitation Frequency Data Server (PFDS) for Atlas 14. This task was completed by processing raster data for the study events based on a HUC-10 level.The excess rainfall values were spatially averaged from raster data using the zonal statistics toolset in ESRI's ArcGIS. The maximum rainfall values, based on a HUC 10 level were selected as input for the resulting HEC-HMS model.

In addition to the Atlas 14 precipitation values, ESRI's ArcGIS software and supporting toolsets were used to process the initial terrain data, delineate drainage basins, and develop basin parameters for the study area. For this analysis, the SCS curve number method was selected to estimate losses due to varying landuse. The weighted Curve Number for the watershed was developed using the 2011 National Land Cover Database, NRCS's SSURGO Soil Surveys and TR-55 runoff curve numbers, and ESRI's ArcGIS software. The watershed was assumed to be at Antecedent Moisture Condition II (average moisture condition). To apply the rainfall, an SCS Type II rainfall distribution was used based to distribute the rainfall across the basin. Table 1, shown below, lists the initial and excess rainfall used for the hydrologic analysis.

Table 1: List of rainfall and peak runoff volume at different recurrence interval

Recurrence Interval (% chance)	NOAA Atlas 14 Rainfall (in)	Excess Volume (in)
10	5.60	3.52
4	6.89	4.41
2	7.52	5.28
1	8.51	6.21
0.2	11.04	8.64
1-plus	10.76	8.36
1-minus	6.68	4.50

After determining the excess runoff in HEC-HMS for the watershed, it was applied to the 2-D hydraulic model as a rain on grid scenario.

2.3. Hydraulics

For all streams identified in the Cache Watershed, the BLE process uses ESRI ArcGIS software and toolsets to create the HEC-RAS layers used for geometric data development and extraction. Additionally, the hydraulic modeling and mapping for this BLE process was conducted using the USACE's HEC-RAS 5.0.3 software package.

Streams

The streamlines used for determining what areas needed to be modeled were taken from the CNMS dataset. They were then expanded to include streams that extended up to a contributing drainage area of approximately 1 sq. mile. These streams were then reviewed and updated to match aerial imagery and detailed topographic data, as needed.

Hydraulic mesh (2-D analysis)

Hydraulic modeling for the Cache Watershed BLE Analysis was computed using 2-D analyses to better reflect the large, flat, and interconnected floodplains. To perform this modeling, 2-D capabilities of the HEC-RAS 5.0.3 was utilized. With a 2-D model, the area is modeled using a topographic mesh rather than a series of cross sections down the longitudinal axis of the stream reach, as is done in a 1-D model. The HEC-RAS mesh consists of computational cells that are assigned elevations and roughness values along the cell faces that represent the topographic surface and frictional characteristics of the area and and volumetric relationships for the cell area, respectively. The use of the 2-D model allows for more detailed resolution in water surface elevations, velocities, and flows than is possible with a 1-D model that is only capable of computing the average water surface elevations, velocities, and flows for three general regions at a cross section. Based on engineering judgement, breaklines were defined along the levees, dams, roads, culverts and elevated berms as seen on the topography. It is necessary to draw breaklines as it makes sure that the flow across the cell faces is blocked by the elevation of the structure along the break line.

Parameter Estimation

The Manning's "n" values used were based on engineering judgment and using the 2011 National Land Cover Data (NLCD) dataset. Table 2 lists the landuse and roughness coefficients used in this analysis.

Table 2: Manning's "n" Coefficients

Material Type	Manning's "n"
Open Water	0.01
Developed, Open Space	0.04
Barren Land (Rock/Sand/Clay)	
Grassland/Herbaceous	0.05
Pasture/Hay	
Emergent Herbaceous Wetlands	
Developed, Low Intensity	0.06
Shrub/Scrub	
Cultivated Crops	
Developed, Medium Intensity	0.08
Developed High Intensity	0.10
Deciduous Forest	
Evergreen Forest	
Mixed Forest	
Woody Wetlands	

Boundary Conditions

For this BLE analysis, the downstream boundary conditions are set to be normal depth slope. The computed slope is based on topographic data from the downstream limits of the modeling.

Model Calibrations

No calibration was performed on these streams.

2.4. Quality Control

Throughout the BLE analysis, quality checks were performed. These checks included review of topographic data processing, hydrologic parameters being applied, checking for complete model coverage, adjusting the mesh cell sizes, adjusting mesh boundaries, adding breaklines along structures, as required, and review of the final mapping results.

Significant efforts were made to resolve errors found during these quality checks.

2.5. Mapping

Following the hydraulic analysis, the model results were then imported into the HEC-RAS RAS Mapper tool to map floodplain boundaries for the model extent. This tool uses a routine that develops water surface elevation grids based on the 5-foot cell size DEM from Section 2.1. For this BLE analysis, mapping results were developed for seven (7) events. These events were the 10-, 4-, 2-, 1-, 0.2-percent-events and the 1-percent-minus and 1-percent plus boundaries.

Once the floodplain boundaries were created, the resulting floodplain data were smoothed and small polygons (less than 0.25 acres) and small disconnected fragments were removed. After the initial boundary edits, the resulting floodplain boundaries were merged into a single watershed based map boundary. For this BLE process, only the 1-percent-annual-chance floodplain is reported on the workmaps. Workmaps were generated to provide a graphical comparison of the effective floodplain boundaries to that of the BLE processed streams. These workmaps are provided in Appendix A – Workmaps.

Once the map boundaries were cleaned, the resulting rasters (Water Surface Elevation, Depth, etc.) were developed with the raster set to correspond in extent to the cleaned polygon boundary. This ensures that the water surface raster and the floodplain boundary are consistent with each other. The depth raster product was created by performing a raster subtraction with the water surface elevation raster and the ground DEM. Once complete, the resultant depth grids were used to perform an updated Flood Loss Analysis for the watershed using the HAZUS program.

3. Submittal

All information, data, and files for the Cache Watershed BLE process are uploaded to the FEMA MIP and provided digitally in electronic format in a directory structure provided below.

08020302\Cache Watershed BLE

- **\General**
  - Project Narrative (PDF)
- **\Hydraulic_Models**
  - **\08020302\08020302_CacheRiver**
    - HEC-RAS model
- **\Spatial_Files**
  - Cache_Watershed (file geodatabase format)
- **\Supplemental_Data**
  - **\CNMS_Update**
    - CNMS database update (file geodatabase format)
  - **\HAZUS**
    - Loss Analysis project
- **\Appendix A – Workmaps**
  - Terrain and Workmap Index (PDF)
  - Workmaps (PDF)
  - Workmap Index (SHP format)

4. References

1. USGS. Multi-Resolution Land Characteristics Consortium. *National Land Cover Database 2011*. (http://www.mrlc.gov/nlcd2011.php).

2. NOAA. Precipitation-Frequency Atlas of the United States, Atlas 14. (http://hdsc.nws.noaa.gov/hdsc/pfds/).

3. Chow, Ven T. *Open Channel Hydraulics*. Caldwell, NJ: Blackburn, 1959. Print.

4. U.S. Army Corps of Engineers, Hydrologic Engineering Center. (September 2016). HEC-RAS River Analysis System, Version 5.0.3. Davis, California.

5. FEMA, "Guidance for Automated Engineering", May 2016.(http://www.fema.gov/media-library-data/1469144112748-3c4ecd90cb927cd200b6a3e9da80d8a/Automated_Engineering_Guidance_May_2016.pdf).