# Automated Engineering Report

Kickapoo Watershed

Wisconsin Department of Natural Resources

June 5, 2017

# 1. Project Description

Large Scale Automated Engineering (LSAE) was performed for the Kickapoo Watershed in May of 2017 by the Wisconsin Department of Natural Resources (WDNR). The purpose of the study was to assess the validity of all effective Zone A study reaches within the watershed, and provide new models that can be upgraded to model backed Zone A studies in the future. The procedures described in the FEMA guidance "Automated Engineering" dated May, 2016 were followed. This study was performed as part of FEMA's Risk MAP initiative.

# 2. Initial Validation Checks

The three Initial Assessments were first performed in order to determine which reaches may need to be modeled with LSAE. The table below summarizes the finding of those three checks:

| ***County*** | ***Check for Significant Topography Updates*** | ***Check for Significant Hydrology Changes*** | ***Check for Significant Development in the Watershed*** |
|---|---|---|---|
| Vernon | 2010 is the latest LiDAR and was used in the 2012 FIS. It passes FEMA Vertical Accuracy Requirements. **PASS** | Most approximate studies appear to use 2003 regression. Some studies may use gage analysis or use detailed study flows (Kickapoo River). Study date approximately 2011. No new regression equations available. **PASS** | For each HUC12 watershed within the Kickapoo watershed, checked the percentage of any intensity "Developed" (values 21-24) landuse from the 2011 NLCD. All watersheds were between 4-7 percent developed (<15%). **PASS** |
| Richland | 2010 is the latest LiDAR. It passes FEMA Vertical Accuracy Requirements. It was likely used for Zone A studies, referenced 'WDNR 2013'. The FIS doesn't specifically list the LiDAR date. **PASS** | Study date 2013. Approximate studies use 2003 regression. No new regression equations available. **PASS** | For each HUC12 watershed within the Kickapoo watershed, checked the percentage of any intensity "Developed" (values 21-24) landuse from the 2011 NLCD. All watersheds were between 4-7 percent developed (<15%). **PASS** |
| Crawford | 2010 and 2011 is the latest LiDAR . It passes FEMA Vertical Accuracy Requirements. It was likely used for Zone A studies, referenced | Study date 2013. Approximate studies use 2003 regression. No new regression equations available. **PASS** | For each HUC12 watershed within the Kickapoo watershed, checked the percentage of any intensity "Developed" (values 21-24) landuse from the 2011 NLCD. All watersheds were |

| *County* | *Check for Significant Topography Updates* | *Check for Significant Hydrology Changes* | *Check for Significant Development in the Watershed* |
|---|---|---|---|
| | 'WDNR 2014'. The FIS doesn't specifically list the LiDAR date. **PASS** | | between 4-7 percent developed (<15%). **PASS** |
| Monroe | Previous Zone A models and mapping based on 20' contour USGS topo maps. Some areas in the Kickapoo watershed were digitized where no TVC's were available. 2010 terrain for Monroe Co has vertical accuracy of 0.95' (29 cm). This does not pass the highest FEMA standard (High Flood Risk, Flattest slopes), but is suitable for Zone A's and this very hilly terrain. **FAIL** | Study date 2007. Approximate studies that were modeled use 2003 regression. No new regression equations available. **PASS** | For each HUC12 watershed within the Kickapoo watershed, checked the percentage of any intensity "Developed" (values 21-24) landuse from the 2011 NLCD. All watersheds were between 4-7 percent developed (<15%). **PASS** |

From the Initial Assessment, the approximate studies in Monroe County are the only ones that need to be modeled with LSAE. Previous mapping was either digitized or modeled with 20' USGS contours, which do not meet FEMA SID 43. All other counties have recent model backed zone A's with LiDAR that meets SID 43. New USGS regression equations are on the horizon for Wisconsin, but are not available yet at the time of this study. There are no HUC12 watersheds in the study area that have more than 15% developed area.

## 3. Hydrology

Streamstats is not yet fully implemented in the State of Wisconsin. Therefore, the Arc Hydro extension for ArcGIS 10.2.2 was used to delineate watersheds, extract regression parameters, and compute the discharges based on the 2003 USGS regression equations. Delineations and slope calculations were based on the statewide preprocessed 10-meter National Elevation Dataset (NED).

First, a batch point file was created to define all locations where a discharge would be required (outlets, major confluences, and some additional road crossings). Basin delineation and parameter extraction were then performed in batch mode. Regression discharges were calculated individually. A spreadsheet was created and saved for each subbasin, showing the parameter values and discharges. The spreadsheet verifies whether

or not parameter values for each subbasin are within the acceptable range for the equations.

The 2003 regression equations do not provide a 0.2% annual chance discharge. Therefore, a flood frequency – discharge plot was created for each subbasin to extrapolate to the 0.2% annual chance frequency discharge.

The Kickapoo watershed is in Hydrologic Region 1. The Equivalent Standard Error (ESE) of this equation for the 1% annual chance recurrence interval is 44%. This error percentage was used to determine the 1%+ and 1%- discharges.

# 4. Hydraulics

LSAE studies were modeled using the Army Corps of Engineers HEC-RAS version 5.0.3 software. HEC-GeoRAS version 10.1 for ArcGIS 10.2.2 was used to develop the geometry data and perform the floodplain mapping.

## 4.1 Terrain Data

Monroe County LiDAR data was collected in 2010. The data was processed countywide and converted into a 5-foot DEM in the NAVD88 (2012) vertical datum. The horizontal coordinate system used for the project was NAD 1983 HARN WISCRS Monroe County (US Feet). The 5-foot DEM was used for cross section development and floodplain delineations.

## HEC-GeoRAS Geometry Setup

## 4.2 Profile Baselines

Where available, breaklines from the 2010 LiDAR data in Monroe County were used to define the profile baseline. These were generally left and right edge of water lines, so the *Collapse Dual Lines to Centerline* function was used in ArcMap to create a single centerline. This covered approximately 2/3 of the study reaches. The remaining profiles baselines were from the 24K Wisconsin hydrography layer, and adjusted where they grossly crossed numerous contours and wandered out of the natural floodplain.

## 4.3 Cross Sections

Cross sections were manually digitized approximately every 500 feet. A smaller spacing was used for steeper streams or in areas with varied topography. A point layer was created with a point automatically located every 500 feet along the profile baseline to aid in this process.

Cross sections were digitized left to right looking downstream. Cross sections were oriented perpendicular to flow as much as possible. Four cross sections were placed at each structure assuming a 1:1 contraction and a 2:1 expansion to facilitate future model upgrades. The structures will not be modeled during LSAE.

## 4.4 Banks

Bank lines were not digitized for LSAE. Bank stations are set at the first and last station point of each cross section.

## 4.5 Manning's n

The 2011 NLCD was clipped to the Kickapoo Watershed and used to create a Manning's n layer. The following n values were assigned to each land use category:

- Barren Land 0.045
- Cultivated Crops 0.045
- Deciduous Forest 0.075
- Developed, Low Intensity 0.045
- Developed, Medium Intensity 0.060
- Developed, High Intensity 0.075
- Developed, Open Space 0.035
- Emergent Herbaceuous Wetlands 0.045
- Evergreen Forest 0.075
- Hay/Pasture 0.045
- Herbaceuous 0.045
- Mixed Forest 0.075
- Open Water 0.035
- Shrub/Scrub 0.075
- Woody Wetlands 0.075

N Values were extracted along each cross section in HEC-GeoRAS. Polygons were dissolved by n value to reduce the number of horizontal variation breaks in HEC-RAS.

## 4.6 Flowpaths

The left and right flowpaths were not digitized for LSAE. The profile baselines were used for the channel flowpath. The channel reach lengths will be used for the left and right reach lengths.

# HEC-RAS Model Setup

## 4.7 Cross Sections

Cross section elevation data was extracted from the 5-foot DEM in GIS.

## 4.8 Reach Lengths

The channel reach lengths were copied to the right and left reach lengths.

## 4.9 Contraction / Expansion Coefficients

Assumed typical values of 0.1 / 0.3 for the contraction / expansion coefficients at all cross sections

### 4.10 Discharges

Discharges were from the 2003 regression equations, described in section 3. The 2003 regression equations do not provide a 0.2% annual chance recurrence interval, therefore this was not modeled. The following profiles were included in the model: 10%, 4%, 2%, 1%, 1%-, and 1%+.

### 4.11 Downstream Boundary Condition

In general, known water surface elevations were used where possible from the receiving stream if it was studied in detail. Drainage areas were compared to make a determination of coincident peaks, and if true the same recurrence interval elevation was applied. If peaks were non-coincident, the 10% annual chance elevation from the receiving stream was applied for all profiles. For the tributaries to Brush Creek and Moore Creek, junctions were used assuming coincident peaks. The following assumptions were made on the remaining waterways:

*Billings Creek*: Normal Depth to match Vernon county Zone A elevation.

*Brush Creek*: Known starting water surface elevations from Brush Creek detailed study. Assume coincident peaks at Upper Brush Creek confluence.

*Cook Creek*: Tried assuming non-coincident peaks but it resulted in critical depth. Used normal depth instead.

*Kickapoo Trib 1*: Known starting water surface equal to the 10% annual chance Kickapoo River elevation. Assumed non-coindident peaks.

*Moore Creek*: Known starting water surface elevations from the Kickapoo River detailed study. Assumed coincident peaks.

*Poe Creek*: Assumed non-coindident peaks but it resulted in critical depth. Used normal depth instead.

### 4.12 QC

The model was reviewed to be sure cross sections contained all profiles, and there were no major problem areas with profiles crossing. CHECK-RAS was run to look for other modeling errors and these were addressed as necessary.

## 5. Floodplain Mapping

Floodplain mapping was performed in ArcGIS with the HEC-GeoRAS extension. Cross sections were extended as needed to map to high ground around river bends and up backwater areas. The following profiles were mapped: 1%, 1%-, and 1%+. The 1%

floodplain was then cleaned up using automated *aggregate* and *smoothing* functions, and hydraulically disconnected flooded areas were manually removed.

## 6. Comparison of Automated Engineering and Effective Zone A

For the A Zones in the Kickapoo watershed within Monroe County, a comparison to the Automated Engineering was used to determine validation status. The method compares the Effective Zone A floodplain boundary to the 1%+ and 1%- flood profiles from the Automated Engineering, as well as, considers a vertical and horizontal tolerance. The following steps were taken to setup the validation checks:

1. Sample points were obtained at and even spaced distance (50 feet) along the Effective Zone A floodplain boundary.
2. Raster Grids were created using interpolated water surface elevations for the Automated Engineering for the 1%+ and 1%- profiles.
3. The Automated Engineering 1%+ and 1%- water surface elevations obtained from the raster grids are assigned the sample points.
4. The ground elevation from the LiDAR used in the Automated Engineering was assigned to the sample points.
5. Using the Zonal Statistics Tool in ArcMap, the minimum and maximum ground elevation within 75-feet (horizontal tolerance) was assigned to the sample point.

Next, several checks were performed for validation. If a sample point failed any of the checks, the point failed validation. The vertical tolerance used during the check is equal to one half the contour intervals used to map the Effective Zone A floodplains. In this case, the Effective Zone A's utilized USGS topographic mapping with 20-foot contour intervals. Therefore the tolerance used for the vertical check was 10-feet. The following checks were completed for validation:

1. Check if 1%+ WSE >= the 1%- WSE.
   **All points passed this check.**
2. Vertical check:
   1%- WSE – 10ft <= Topographic Elevation <= 1% plus WSE + 10
   **391 points failed this check.**
3. Horizontal check:
   1% plus WSE >= Minimum Elevation with 75ft AND
   1%- WSE + Maximum Elevation with in 75ft
   **994 points failed this check**

The sample points were then grouped by HUC12 to calculate the percentage of passing points by study reach. Validation is based on the FEMA Floodplain Boundary Thresholds for the Risk Class. All Effective Zone A's in this comparison fall with Risk Class C and therefore requires 85% of the points to pass within the HUC12 to pass. The table below summarizes those results:

| HUC12 | TOTAL | PASS | FAIL | %PASS | VALIDATION |
|---|---|---|---|---|---|
| 070700060101 | 171 | 155 | 16 | 90.64% | PASS |
| 070700060102 | 1314 | 595 | 719 | 45.28% | FAIL |
| 070700060103 | 303 | 99 | 204 | 32.67% | FAIL |
| 070700060104 | 323 | 177 | 146 | 54.80% | FAIL |
| 070700060301 | 471 | 454 | 17 | 96.39% | PASS |
| 070700060302 | 239 | 172 | 67 | 71.97% | FAIL |
| **TOTAL:** | **2821** | **1652** | **1169** | **58.56%** | |