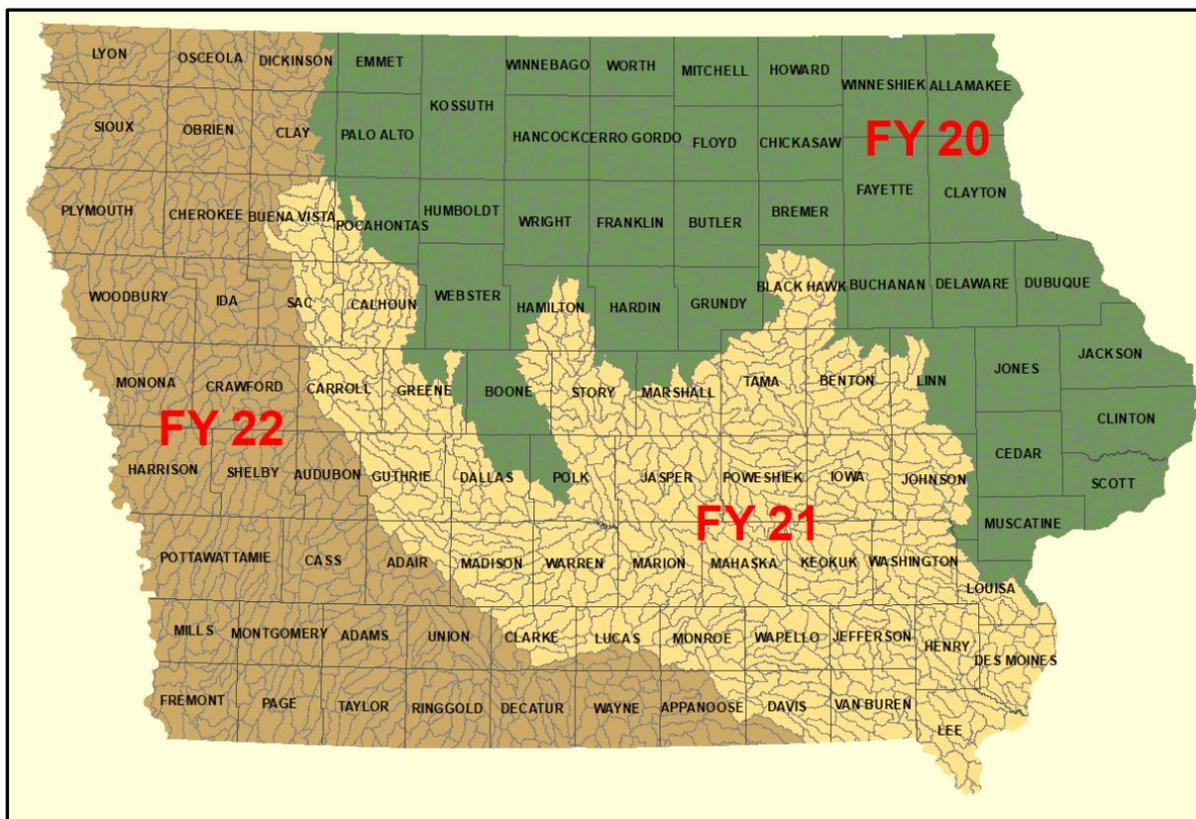# Iowa CTP Preference Guidance

## 2D Base Level Engineering (BLE)

*Iowa Department of Natural Resources*



**May 2025 (Version 3)**

## Preface

The purpose of this guidance is to document Iowa Cooperating Technical Partnership (CTP) preferences that are supported by FEMA guidance but may not be the primary or only way to process and represent the flood risk.  Guidance was developed for performing 2D BLE hydraulic modeling and mapping to establish consistent methods amongst mapping partners. This document acknowledges the input of AECOM and Atkins engineering and mapping subject matter experts.

# Base Level Engineering (BLE)

## 1.0    Pre-Processing

- Modeling will generally be done at the HUC10.  However, the HUC10 may be combined or subdivided to remain around 300 square miles per model.

    o Naming convention

        ▪ HUC10 – follow HUC10 name
        ▪ Eg. 1017020312
        ▪ Sub-HUC10 –
        ▪ Eg. 1017020312#
        ▪ Where # = A to Z

- HUC10 Boundaries

    o Sub-basins in series shall include an area of overlap with adjacent sub-basins where flow is mostly one-dimensional in nature.  Overlap areas help provide smooth tie-ins across models. The water surface elevation tie-in should be less than 0.5 ft.
    o Slightly different model extents for results and models are necessary to appropriately model flood risk and create continuity.
    o There may be adjustments to HUC10 boundaries for the purpose of tie-ins as long as it is documented and coordinated.
    o Models areas may be larger or different than HUC10 to capture specific hydraulic, but the modeling and mapping results will be provided at HUC10 boundaries.
    o Model extents will consider the following:

        ▪ Confluences
        ▪ Buffers of 30 ft
        ▪ Urban areas

            - Efforts shall be made to avoid placing towns in overlap areas. This is to avoid having 2 models for populated areas so there is no question on which model to use when assessing elevations at a structure

    o Manual edits of the sub-basin boundaries shall be done, as necessary if it is noticed that not all drainage area is being captured in one basin after a model is run.

- Topographic Data

    o The topographic data used in the analyses shall meet FEMA SID #43. Iowa DNR will use the most current LiDAR collected in 2019, 2020 and 2021. As data is made public Iowa DNR will notify those working on the project
    o No adjustments should be made to the hydraulic model terrain so that it can be used by other users with no customized changes and no version issues.

- The development of the 1 square mile stream network used for modeling and mapping may require re-sampling DEM and manual edits.

## 2.0  Modeling

- HEC-RAS Version 6.X will used for hydrology and hydraulics.

- An important assumption is that a single storm will cover the entire HUC10 watershed. If this assumption is invalidated, such as due to model calibration results, creating smaller model areas may be necessary.  This will address concerns on probability.

- Rainfall Distribution

  o The NRCS nested rainfall distribution for the correct Midwest Southeast (MSE) region, which is based on a regional analysis of Atlas 14 data shall be utilized. The NRCS document ratios shall be used to determine the correct region.

- Frequencies: 10%, 4%, 2%, 1%, "1%+", and 0.2% annual-chance floods

- Use HEC RAS's built in spatial infiltration layer with soil losses in combination with the following layers as part of the overall model.

  o NLCD dataset
  o SSURGO Soils dataset

- Manning's "n"

  o Mapping of NLCD land use categories with specific channel and shallow flow Manning's "n" values. (See Appendix A)
  o The channel and overbank should have different "n" values for same land use type to account for deep, swift flow vs. shallow, overland flow.
  o Enforce an appropriate stream buffer into land use layer and assign a Manning's "n" value for those channel buffers.
  o Adjustments may be made to Manning's "n" based on land use as part of model calibration.

- Widths of embankment openings, offset break lines, shall be adjusted for larger drainage areas to reflect larger openings. (Iowa DOT dataset)

- Incorporate manual edits near and in developed areas as warranted and assign appropriate Manning's "n" values.

- Create a shapefile for internal connections needed for downstream inputs, locations of gages, and other flow comparison locations.

- Import basin boundary, breaklines, hydroDEM, and land use into HEC-RAS model.

- Create the 2D mesh starting with an initial mesh of no greater than 200 feet.

  o Mesh Size

    - Nominal mesh size:  200 ft * 200 ft
    - Minimum mesh size:  50 ft * 50 ft
    - Developed areas:  50 ft * 50 ft

- - - Steep areas: may need to have smaller mesh sizes defined by refinement regions

- Breaklines

    - Stream Banks (top of bank shapefile)

        - Use shapefile from DNR
        - If no stream banks are available, then use stream centerline to define cell faces

    - Stream centerline to have 100 ft cells and may be refined based on engineering judgment.
    - Levees (from NLD)
    - Dams
    - Large water bodies
    - Lakes
    - Roads

        - Select all roads that intersect streamlines to 1 sq. mi. drainage area and clip with 500-yr floodplain
        - Look at dataset
        - Engineering judgement

    - Railroad

        - Statewide railroad dataset

    - Ensure proper enforcement of all breaklines, using manual edits where needed.

- Terrain Modification

    - Use near hydraulic features to develop mesh cells that allow flow through embankments.
    - At long culverts, use structure or long cells (adjusted in HEC-RAS) to handle flow across embankments (site specific solution)
    - Terrain modification will be used to allow flow to pass through structures
    - Dams - Using the National Inventory of Dams (NID) to search for purpose, hazard classification and private/public.

        - Public Dams

            - For Large Dams/Reservoirs with a purpose of flood risk reduction

                - Match the 1% elevations
                - Main concern is matching downstream flows
                - Then map the 1% reservoir elevation
                - Make sure the tributaries do not come in to high

            - All others:

                - Map the flood pool at the axillary spillway height

- Show protection by drawing breakline on dam.
- And let the water spill out the spillway in the modeling

  - Private Dams

    - Map with no protection from the 1% annual chance storm
    - Breakline at the top of the dam with a burn line through it at the width of the channel.

- Refinement Zones

  - Stream corridors
  - Urban Areas

    - S_POL_AR from effective or prelim FIRM DBs
    - Cell Size: 50 feet

  - Levee Areas

    - Levee protected areas – from the NLD

  - Dam or critical structure embankment areas

- Non-Refinement Zones

  - Large Water Bodies using edge of water shapefile
  - Cell sizes able to be increased above 200 feet.

- Boundary Conditions

  - Add boundary conditions lines for flow entering or exiting the model. Normal depth shall be applied for flow leaving the model
  - Inflow hydrographs shall be applied for flow entering the model using a DSS file.
  - Include overlap area with upstream and downstream models to assist with model tie-ins.
  - Add internal connections for: a. Outflow location that will be used in the downstream model (upper end of the overlap area).

- For large Federal Reservoirs, coordination shall be made with the appropriate federal agency in determining appropriate discharges and static elevations for reservoirs for each storm event. See above dams section.

- Plan Settings

  - Set up unsteady model plan with the variable time-step option using the following settings: a. Duration of run is typically between 3 to 7 days (run time depends on size of full watershed)
  - Use Diffusion Wave Equations
  - Maximum Courant of 3 should be used (1.5 to 0.75 should be the goal).

- o Number of steps below Minimum before doubling = 5. Baseline timestep should be 30 seconds, and the courant settings are used with the adaptive time step option.
  - o Maximum number of doubling and halving base time step = 2
  - o Hydrograph output interval = 1 Minute
  - o Mapping output interval= 15 Minutes (May need to decrease during review of model stability)

- Resolve instabilities and high velocities (need to add a threshold)

- Evaluate areas with long ponding durations and adjust offset breakline widths where there is unintended ponding.

- Internal QA/QC review is completed based on FEMA standards and these defined parameters.

- All internal review comments addressed and backchecks completed.

## 3.0 Calibration

- Calibration Priorities

  - o Priority One

    - ▪ Model flows will be calibrated to flows observed at USGS Gages on studied stream
    - ▪ Adjust CN, Manning's "n" and check breaklines for unintended storage to properly calibrate model flows.

  - o Priority Two

    - ▪ Flows

      - • Use effective flows (non-regression) for calibration with caution. Engineering judgement on date and methods used to determine effective flows.
      - • Use regression flows as a "reasonableness check" in ungaged areas of the model.
      - • Adjust CN, Manning's "n", and check breaklines to properly calibrate model flows.

    - ▪ WSEL

      - • Use HWMs as a "reasonableness check" – if the HWM WSEL of a known frequency is within the WSEL at model computed frequencies
      - • For large reservoirs check 1% WSEL if computed for "reasonableness" with rating curve (if available)

- Calibration Tolerances

  - o USGS Gages

    - ▪ Upper and lower bound of 68% confidence interval – i.e. +/- 1%

  - o Regression

- Upper and lower bound of 68% confidence interval or Standard Error of Prediction – i.e. +/- 1%
- 80% of locations fall within tolerances above

- Calibration Frequencies

  o 1% annual chance model to be calibrated, additional plans will use the same model geometry and plan settings with updated hydrology inputs.

- Calibration Locations

  o Number of Calibration and/or "reasonableness" locations per HUC-10s

    - 5 – 10 locations per HUC-10 watershed

      - Varying drainage areas and streams within each model
      - 1-2 with DA<5 sq. mi.

    - Locations to include

      - Gages streams - USGS gage locations
      - Ungaged streams – above confluences
      - Choose locations that will provide a representation of the full watershed

## 4.0    Floodplain Mapping

- Mapping & Grids

  o Mapping Frequencies – 1% and 0.2%
  o Grids Frequencies - 10%, 4%, 2%, 1%, "1%+", and 0.2% annual-chance floods
  o Grid products – WSEL, depth, velocity grid (1% and 0.2%), Annual chance, and 30-year grids
  o Mapping output interval= 15 Minutes (May need to decrease during review of model stability)
  o Use of "depth weighted faces" HEC-RAS / RASMapper render mode for interpolating WSE cells to raster grids. This helps minimize "cupping." Use contractor preferred method to reduce "cupping" effects on the floodplain
  o Floodplain mapping on same grid as (non-hydro-enforced) terrain.
  o Cleanup

    - Filter out all floodplain that has a depth of less than 1ft, and remove all floodplain polygons that do not touch the 1 square mile.
    - Once a floodplain becomes disconnected due to removal of the 1ft of depth, the disconnected floodplain upstream should be removed unless:
    - Upstream of the disconnect there is additional connected floodplain that goes for a linear mile or more;
      - It is clear there is a channel present;
      - It is clear there is a hydraulic structure connecting the areas and/or
      - In populated areas where it is obvious structures are causing the less than 1ft disconnect.

- Disconnected areas will only be connected when there is a channel present. This will be completed by buffering the stream so the floodplain goes from bank to bank.
  - Other areas will be left disconnected.
- Then clean up the boundary with integer polygons to remove backwater that increases by more than a foot up non 1 square mile streams.
- Remove "holes" less than 15,000 sq. ft. (from best practices of removing small polygon and holes)
- Remove polygons that are less than 1,000 sq. ft. (1%) and 5,000 sq. ft. (0.2%), unless they meet the rules above
- Remove disconnected polygons (not linked with main flooding source) smaller than 40,000 square feet, or which are within 1 linear mile of the upstream end of 1 square mile drainage area centerlines.
- Manually edit SFHA to include water bodies as visible on imagery or provided in the waterbodies shapefile provided by Iowa DNR where the model does not compute wet cells (due to topo issues).

- Smoothing and generalizing

  - Generalizing floodplains at 1-foot tolerance using the Zhou-Jones simplification algorithm, or lower tolerances for other generalization routines.
  - Smooth final floodplains to 2.5 times the cell size of terrain.

- SFHA and Drainage Area

  - Using terrain, the drainage areas above 1 sq. mi. will be determined.
  - The draft and final SFHA will be trimmed to areas with drainage area of 1 sq. mi. or greater (i.e. dropping off floodplains with drainage area less than 1 sq. mi.)
  - Floodplains will be developed for all areas (regardless of drainage area) that have effective SFHAs.
  - Floodplains for water bodies 40 acres or larger and with average depths of 1foot or greater will be included in the SFHA.

- Incoming tributaries with drainage area less than 1 sq. mi.

1% Floodplains for such tributaries will only be mapped as backwater from main streams.0.2% floodplain will be mapped for the entire tributaries regardless of drainage area.

- Backwater

  - Floodplains for backwaters will be mapped into tributaries with drainage area less than 1 sq. mi. Floodplain will be clipped to the extent of the nearest whole foot backwater elevation.
  - 0.2% floodplain will be mapped for the entire tributary, regardless of drainage area, if backwater is mapped on the 1%.

- Pluvial Flooding

  - Pluvial flooding connected to the SFHA above 1 sq. mi. will be include in final SFHA but disconnected pluvial flooding will not be.

## 5.0    Independent QA/QC & Other Considerations

A hydrologic and hydraulic Independent Technical Review (ITR) will be performed on all models in the BLE phase and Data Development phase.

The specific items for the independent QA/QC will be finalized once the modeling approach is finalized.

## 6.0    Deliverables

- MIP Deliverables

Data will be submitted under Hydraulics, Independent QAQC, Floodplain Mapping, Draft DFIRM, and Outreach tasks for each HUC (size dependent on MIP setup).

- The specific task deliverables shall follow the current format of FEMA Data Capture (DC) Technical Reference. Flood Risk Products for Depth, Water Surface Elevation and Velocity grids will be submitted with the Floodplain Mapping Task under Supplemental Data.

- Iowa DNR Viewer

  - Models at the HUC-10 level

  - Final DFIRM database

  - Depth Grids for 10%, 4%, 2%, 1%, "1%+", and 0.2% annual-chance floods

  - Water Surface Elevation Grids for 10%, 4%, 2%, 1%, "1%+", and 0.2% annual-chance floods

  - Velocity Grids for 1% and 0.2% annual-chance floods

  - Raw Stormwater Grids for 1% and 0.2% annual-chance floods

## 7.0    Standards

The BLE deliverables shall meet the standards listed in the funding associated Mapping Activity Statement (MAS #30, #33, and #36) Section 5.  Specifically, the standards that will be met are:

- FEMA Policy 204-078-1 Standards for Flood Risk Analysis and Mapping, Revision 10, dated November 2019

- FEMA Guidelines and Standards Master Index (effective at time of MAS executed date)

## Appendix A – Manning's 'N' Values

| NLCD 2016 Land Use Code | | Range of n values in literature | Utilized n-value Channel | Utilized n-value Overbank |
|---|---|---|---|---|
| **Water** | | | | |
| 11 | Open Water - areas of open water, generally with less than 25% cover of vegetation or soil. | 0.001 - 0.06 | 0.013 | 0.013 |

| NLCD 2016 Land Use Code | | Range of n values in literature | Utilized n-value Channel | Utilized n-value Overbank |
|---|---|---|---|---|
| 12 | Perennial Ice/Snow - areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover. | .01 - 0.027 | 0.020 | 0.020 |
| **Developed** | | | | |
| 21 | Developed, Open Space - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes. | 0.01 -0.048 | 0.040 | 0.050 |
| 22 | Developed, Low Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units. | 0.01 - 0.12 | 0.050 | 0.1 |
| 23 | Developed, Medium Intensity – areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units. | 0.01 - 0.1 | 0.050 | 0.1 |
| 24 | Developed High Intensity -highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover. | 0.01 - 0.12 | 0.050 | 0.1 |
| **Barren** | | | | |
| 31 | Barren Land (Rock/Sand/Clay) - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover. | 0.011 - 0.09 | 0.030 | 0.040 |
| **Forest** | | | | |
| 41 | Deciduous Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change. | 0.07 - 0.36 | 0.050 | 0.120 |

| NLCD 2016 Land Use Code | | Range of n values in literature | Utilized n-value Channel | Utilized n-value Overbank |
|---|---|---|---|---|
| 42 | Evergreen Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage. | 0.07 - 0.32 | 0.050 | 0.120 |
| 43 | Mixed Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover. | 0.1 - 0.4 | 0.050 | 0.120 |
| **Shrubland** | | | | |
| 51 | Dwarf Scrub - Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation. | 0.04 | 0.040 | 0.065 |
| 52 | Shrub/Scrub - areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions. | 0.035 - 0.4 | 0.040 | 0.065 |
| **Herbaceous** | | | | |
| 71 | Grassland/Herbaceous - areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing. | 0.022 - 0.36 | 0.035 | 0.040 |
| 72 | Sedge/Herbaceous - Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra. | 0.03 | 0.035 | 0.040 |
| 73 | Lichens - Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation. | 0.027 | 0.035 | 0.040 |
| 74 | Moss - Alaska only areas dominated by mosses, generally greater than 80% of total vegetation. | 0.025 | 0.035 | 0.040 |
| **Planted/Cultivated** | | | | |

| NLCD 2016 Land Use Code | | Range of n values in literature | Utilized n-value Channel | Utilized n-value Overbank |
|---|---|---|---|---|
| 81 | Pasture/Hay – areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation. | 0.033 - 0.325 | 0.035 | 0.040 |
| 82 | Cultivated Crops – areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled. | 0.035 - 0.04 | 0.035 | 0.040 |
| **Wetlands** | | | | |
| 90 | Woody Wetlands - areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water. | 0.037 - 0.14 | 0.060 | 0.120 |
| 95 | Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water. | 0.045 | 0.060 | 0.1 |