Application of HEC software to Periodic Assessment Studies

A series of lectures and workshops were developed for the USACE Dam Safety program to illustrate periodic assessment level of analysis and application of HEC software. The material was posted to the HEC training webpage for the user community to see additional examples for how to apply both HEC-SSP and HEC-HMS to typical study applications. HEC-SSP version 2.1.1 and HEC-HMS 4.2.1 were used in the development of the workshops.

1. **PMP Development Using HMR**

This workshop illustrates a method for developing the PMP using existing guidance documents, HMR 51 and 52, along with existing software, ArcGIS and the DOS based HEC-HMR52 program. The product from the PMP analysis is basin average hyetographs that are then applied to an HEC-HMS model to compute the PMF hydrograph.

The general steps of this workshop are summarized below.

1. Use ArcGIS to determine X, Y coordinate pairs that adequately describe the basin boundary.
2. Use ArcGIS to determine the watershed average PMP for multiple durations and areas as found in the HMR 51 PMP index maps (which have been digitized).
3. Complete the HEC-HMR52 input file and run the DOS program.
4. Load the output from the HEC-HMR52 program into an HEC-HMS model and run a simulation.
5. Apply the HMR52 meteorologic model option in HEC-HMS.
6. Summarize key aspects of other HMRs

2. **PMF Hydrograph Development with existing HEC-HMS Model**

This workshop illustrates one method for developing the PMF given an existing HEC-HMS model. The workshop focuses on using the existing HEC-HMS model and making modifications appropriate for the PMF simulation.

The following major tasks will serve as an outline for the workshop:

1. Summarize model parameters in the existing HEC-HMS model. Choose appropriate model parameters for the PMF simulation
2. Peak the unit response at the dam
3. Configure the model for a PMF simulation
4. Compare PMF results for unit hydrograph peaking scenarios
5. Discussion of validation of an existing model when the existing model is not thoroughly documented.

3. **PMF Hydrograph Development without existing HEC-HMS Model**

This workshop illustrates a method for developing the PMF given existing information in a reservoir regulation manual and historic flows at a USGS gage. A simple precipitation-runoff model is developed where the watershed area at the dam is

modeled as one subbasin.

This workshop focuses on developing unit hydrographs from observed historic events, assigning unit hydrograph durations, transforming unit hydrographs from one duration to another, selecting the most conservative unit hydrograph to be used in PMF modeling, reproducing the unit hydrograph with HMS modeling for PMF analysis, and peaking the unit hydrograph response at the dam.

Both the summation method (S-hydrograph) and HEC-HMS will be used to transform the unit hydrographs to a 1-hour duration. The most conservative unit hydrograph will be selected and used to fit a synthetic unit hydrograph generated by the Clark unit hydrograph method in HMS and peaked for PMF analysis.

The general steps of this workshop are summarized below:

1. Find three historic flow events for the development of the watershed unit hydrograph. One of these events will be the 1972 event of record from the reservoir regulation manual. The other events will be from an analysis of USGS stream gage data upstream of the dam.
2. Obtain hydrograph and hyetograph data for the three events.
3. Remove the baseflow from the three events.
4. Scale the observed flow data to produce unit hydrographs.
5. Determine the duration for each of the unit hydrographs from the excess precipitation of the observed rainfall events.
6. Standardize all three of the unit hydrographs to the 1-hour duration.
7. Fit a synthetic Clark unit hydrograph to the unit hydrograph generated by observed storm analysis.
8. Illustrate the difference between a 20-hour unit hydrograph and a 1-hour unit hydrograph.
9. Select the most conservative unit hydrograph to use to develop the PMF for Sayer Dam.
10. Peak the unit hydrograph response at the dam.
11. Configure the model for multiple PMF simulations.
12. Compare the PMF results from unit hydrograph peaking scenarios.

4. **PMF Routing**

This workshop illustrates how an HEC-HMS model can be configured to route the PMF hydrograph through a reservoir model. Either an existing HEC-HMS can be used or a simple HEC-HMS model can be developed that includes a source element and a reservoir element. This workshop focusses on configuring the reservoir element and applying guidance for computing the PMF stage. For flood flows modeled as part of the PMF stage, the influence of the downstream control operations on the peak pool elevation is generally negligible, due to both the large magnitude of the inflow hydrograph and the accompanying large magnitude of the downstream local flows. Generally, all discharge will be through uncontrolled outlets, spillway, and possibly the dam top as well. Therefore, HEC-HMS provides a computationally efficient and reliable means for determining the peak pool elevation for the PMF.

As stated throughout the workshops, multiple scenarios are required to demonstrate the uncertainty in many of the modeling assumptions that are part of the Periodic Assessment. When computing the PMF stage, multiple scenarios are necessary that evaluate the uncertainty due to the initial reservoir storage condition. The preferred PMF stage is set following guidance in ER 1110-8-2(FR). Other possible uncertainties in reservoir routing include uncertainty in gated spillway operations and reduced capacity of uncontrolled outlets due to debris.

The following major tasks will serve as an outline for the workshop:

1. Compute the one-half PMF hydrograph and import the information into an HEC-HMS model
2. Add a simple basin model with a source element and reservoir element, enter physical information for the reservoir element
3. Compute the simulation that routes one-half the PMF hydrograph through the reservoir and determine the resulting stage five days after significant precipitation
4. Configure an HEC-HMS basin model to route the full PMF hydrograph and compute the PMF stage
5. Compare the PMF stage from multiple initial pool scenarios
6. Discussion point on how to address gated spillways.

5. **Flow Frequency**

In this workshop you will gain experience creating representative instantaneous peak flow and daily inflow data sets to Sayers Dam. Then, you will fit Log Pearson Type III analytical frequency curves to both sets of data to create peak flow- and volume-frequency curves for rare probabilities.

The following major tasks will serve as an outline for the workshop:

1. Create a new HEC-SSP project and import inflow data sets.
2. Create a Bulletin 17 analysis for the instantaneous peak inflows and compute Log Pearson Type III parameters using Bulletin 17C Methodology.
3. Create a Volume Frequency analysis and extract the 1-, 2-, 3-, and 4-day duration flow rates.
4. Create additional Bulletin 17 analyses for the 1DAY, 2DAY, 3DAY, and 4DAY duration peak inflows using Bulletin 17C Methodology.
5. Smooth the computed at-site standard deviation and skew estimates for the volume frequency curves.
6. Output and analyze flow frequency results.
7. Incorporate an expected probability adjustment to each flow- and volume-frequency curve.

Two additional tasks are also included at the end of the workshop:

A. Analyze the differences between Bulletin 17B and Bulletin 17C results.
B. Create an inflow record to Sayers Dam that doesn't contain any missing data.

Then, create a new Bulletin 17 analysis, compute the analysis, and compare against the previously-computed results.

6. **Stage Frequency – Balanced Hydrographs**

In this workshop you will gain experience creating inflow balanced hydrographs to Sayers Dam that are balanced across multiple durations and use different "pattern" hydrographs. You will then compare and contrast the different balanced hydrographs.

The following major tasks will serve as an outline for the workshop:

1. Create a new HEC-SSP project and import an hourly inflow data set.
2. Create a Balanced Hydrograph analysis and generate 3DAY 1-, 0.5-, 0.2-, 0.1-, 0.01-, 0.001-percent balanced hydrographs using the June 1972 event as a pattern.
3. Create additional Balanced Hydrograph analyses using different historical event hydrograph shapes.
4. Create an additional Balanced Hydrograph analysis using the June 1972 event that balances across multiple durations.

Two additional tasks are also included at the end of the workshop:

A. Route the balanced hydrographs that were previously created within an HEC-HMS model.
B. Perform a Coincident Frequency Analysis for the December 2010 event.

7. **HEC-SSP Overview**

In this presentation, you will be shown a summary of the Hydrologic Engineering Center's Statistical Software Package (HEC-SSP). Topics include relevant documentation, the history and evolution of HEC-SSP, an overview of the graphical user interface, preferred Data Storage System (DSS) conventions, existing analysis types, and soon-to-be-released analyses.