APPENDIX D

NJ Department of Agriculture

Model Development and Calibration Figure Appendix

1. Rating Curve Development Strategy

In order to utilize the HEC-RAS model, multiple stream cross sections are needed for the model to compute and balance energy losses from one section to the next. Several different flow rates can be entered into the model, which when calibrated will give an indication of the water surface elevation corresponding to each flow rate value, which is the rating curve as described previously. Investigators used direct field measurements of stream flow to calibrate the HEC-RAS model for in-channel flows, but used traditional “trial and error” methods to calibrate larger, out-of-bank flows. In order to do this, surveyed cross section data, combined with Geographic Information Systems Digital Elevation Model (DEM) data and stream flow logger data was used.

The investigators with the assistance of Monmouth County Office of GIS (GISMO) developed a procedure to use DEM data to define the floodplain portion of the stream cross section, with more highly detailed survey data of the stream channel itself to produce a hybrid cross section model used in HEC-RAS. Survey data was “burned” into the DEM data which was then recompiled to give higher resolution in the channel portion of the DEM. Using a combination of add-on software packages from Environmental Systems Research Institute (ESRI, Inc) and USACOE, GISMO was able to create three dimensional sections or “slices” through the floodplain and through the channel for use in HEC-RAS modeling. The beauty of this system is several-fold: First, the cost for obtaining field survey data is greatly reduced since surveyors do not need to physically survey large transects through the floodplain area. Second, the cross sections are adjustable by software such that additional sections, relocated sections or repositioned sections may be easily created, exported and the RAS model updated and re-run. One significant limit of this system does exist however. The DEM data which is used to depict the floodplain areas must have sufficient resolution in elevation to make floodplain data useful. The amount of resolution needed is dependent on the terrain itself and the level of detail needed in the model.

For example, to use this method to model the Colorado River, elevation resolution of 10 or more meters would be sufficient since the terrain is highly irregular and elevation varies significantly. Error associated with DEM production would be small relative the overall changes in elevation around the Colorado. Also the flow values needed for acceptable model accuracy are high – in the order of hundreds of cubic feet per second or higher. In contrast, the Wreck Pond Brook Watershed terrain is fairly flat, and the level of precision in flow modeling is within a few CFS. These factors dictate that the DEM model have a resolution capable of resolving elevation differences of about 1 foot since much of the hydraulic and hydrologic response in the watershed is governed by small nuances in topography. The State of New Jersey produces and maintains a state-wide DEM data layer, but the maximum resolution is only 10 meters. Fortunately, Monmouth County produces and maintains its own DEM data layer with resolution of about 1 foot which provided the means to develop this hybrid method.

2. Stream Flow and Velocity Measurements.

Investigators utilized a USGS-type current meter mounted on a one-piece wading rod. The Price AA and Pygmy meters were both used to measure flow and velocity. The investigators found that the magnetic head of the Pygmy meter was prone to failure and returned it and had a wire head (cat whisker) pickup installed, which worked flawlessly. The Price AA meter utilized a magnetic head without any failure.

To measure flow at a gage station, a cross section was established using a 100 foot flexible tape reel, with the tape stretched across the section and anchored on both banks. An AquaCalc Pro computer was attached to the current meter/wading rod to record measurements. Stream cross sections were measured in one foot intervals or less to minimize error associated with the USGS method of approximating stream cross section area.

In this method, the stream flow is measured at several stations across the stream. At each station, the distance to bank and stream depth is entered into the AquaCalc Pro, the wading rod is used to adjust the height of the current meter from the stream bottom, and then a flow reading was taken. The AquaCalc Pro was set to measure velocity at a depth equal to six-tenths of the depth at that section. This is considered to be the location where a good "average" flow velocity may be found. In deeper waters, the computer can be set to take two readings, one at 2 tens and another at 8 tenths the total depth. The wading rod is calibrated to facilitate setting the depth of the current meter at 6 tenths readings.

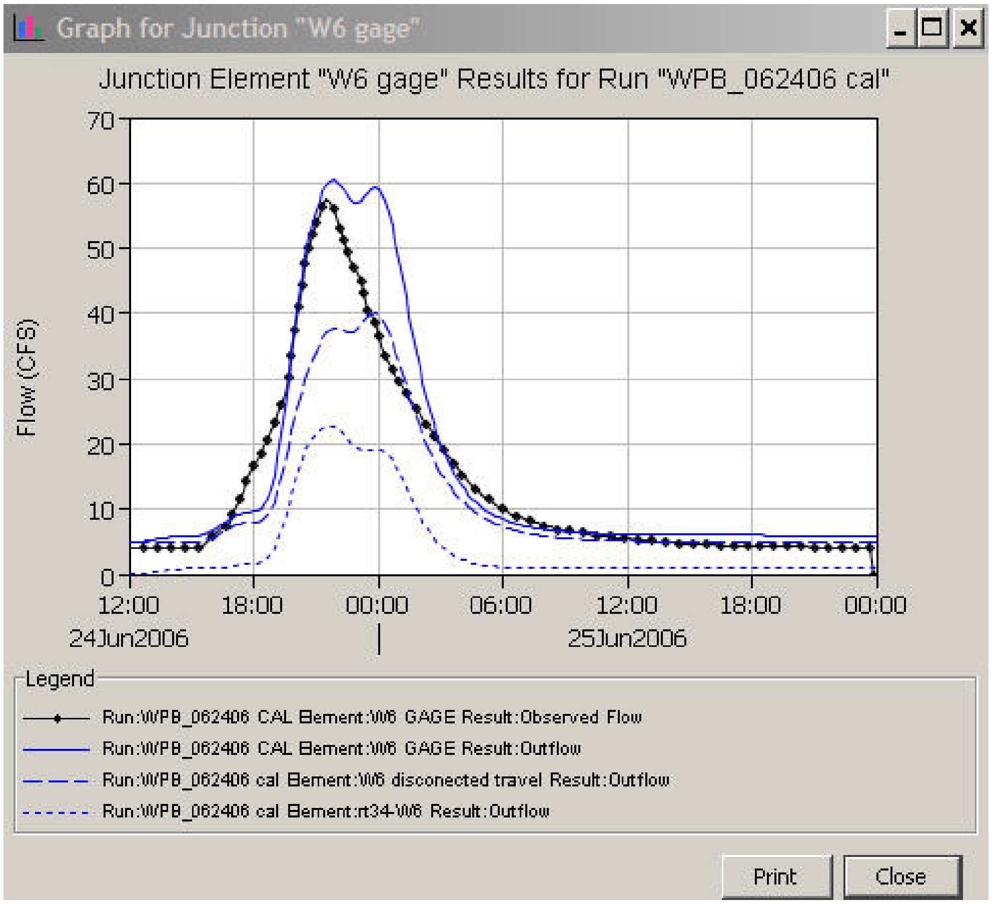
The AquaCalc Pro measures the rotation of the meter and uses internal calibration tables to convert the number of rotations into velocity. Readings are averaged over a forty second period to determine average velocity for that section. The Pro computes the sectional flow rate by averaging the width of each section, multiplied by depth to get a rectangular representation of the area through which that portion of the stream is flowing and then multiplies that flow area by velocity thus computing volume flow rate, or cubic feet per second. Adding all the section measurements across the stream results in the total volumetric flow rate, CFS, for the stream. This method essentially integrates the cross sectional area by approximating small sections of the stream with rectangles. Obviously, the smaller the rectangle (the closer the sections are to each other) the greater the accuracy the final reading will have.

The first reading (near bank) and last reading (far bank) have depth and velocity set to 0.0 which signals the beginning and end of a section measurement. The AquaCalc Pro can also store various user data, including staff and recording gage readings at the beginning and end of the measurement session. Data from the Pro is then downloaded to a PC via proprietary software and cable and is stored in Excel. A single measurement of stream flow and water surface elevation constitutes one data point on the stream rating table curve. Investigators sought to take multiple readings at each gage station, at various depths of water to create a rating curve from base flow to bank full flow. Although the AqauCalc Pro is sealed against moisture, it cannot tolerate submersion or getting soaked in a heavy rainfall. Investigators had to return the computer to the manufacturer for replacement of the mainboard after the unit was "soaked" while taking a measurement during a heavy rainfall event. A clear plastic bag was placed over the unit on subsequent readings during rain events to protect the computer without further incident.

3. Drainage Areas, Curve Numbers and Watershed Lag

Modeling parameters were developed from high resolution (1 foot) digital terrain data from the Monmouth County Office of Geographic Information Systems (MCGIS). Drainage area boundaries were field verified and changes were made to the terrain model to reflect field conditions. Curve numbers were computed by intersecting soil data and landuse data. The resultant GIS data layer was then populated with curve numbers by matching soil-landuse combinations with those shown in NRCS Technical Release 55 (TR-55), "Urban Hydrology for Small Watersheds". Curve numbers were then condensed into more general categories which had similar land use and curve numbers. CN generation was performed by Najarian Associates, of Eatontown, NJ, who was a consultant for a separate watershed study conducted by the town of Spring Lake, NJ, a member municipality in the watershed.

Curve numbers for each soil-landuse polygon were then amalgamated via the TR-55 weighting procedure to produce an overall, subwatershed Curve Number. Lastly, lag time was estimated by measuring stream channel length via GIS and assuming a flow velocity of 1 foot per second. This assumption was based on numerous field observations of velocity metering during watershed storm events. Since this estimate does not, nor could it include stream obstructions and hydraulic residence times in reservoirs, this estimate was used as a "starting point", as was the weighted curve numbers, for final model calibration and verification.



Summary Results for Junction "W6 gage"

Project : wreck Pond   Simulation Run : WPB_062406 cal   Junction: W6 gage

Start of Run :	24Jun2006, 12:00	Basin Model :	WPBstem_062406 cal
End of Run :	26Jun2006, 00:00	Meteorologic Model :	June24_2006
Compute Time :	05Jun2008, 13:25:09	Control Specifications :	june242006 _wpb stem cal

Volume Units : (•) IN ( ) AC-FT

Computed Results

Peak Outflow : 60.5 (CFS)   Date/Time of Peak Outflow : 24Jun2006, 21:50
Total Outflow : 0.66 (IN)

Observed Hydrograph at Gage w6_062406

Peak Discharge :	57.60 (CFS)	Date/Time of Peak Discharge :	24Jun2006, 21:30
Avg Abs Residual :	3.25 (CFS)		
Total Residual :	0.08 (IN)	Total Obs Q :	0.58 (IN)

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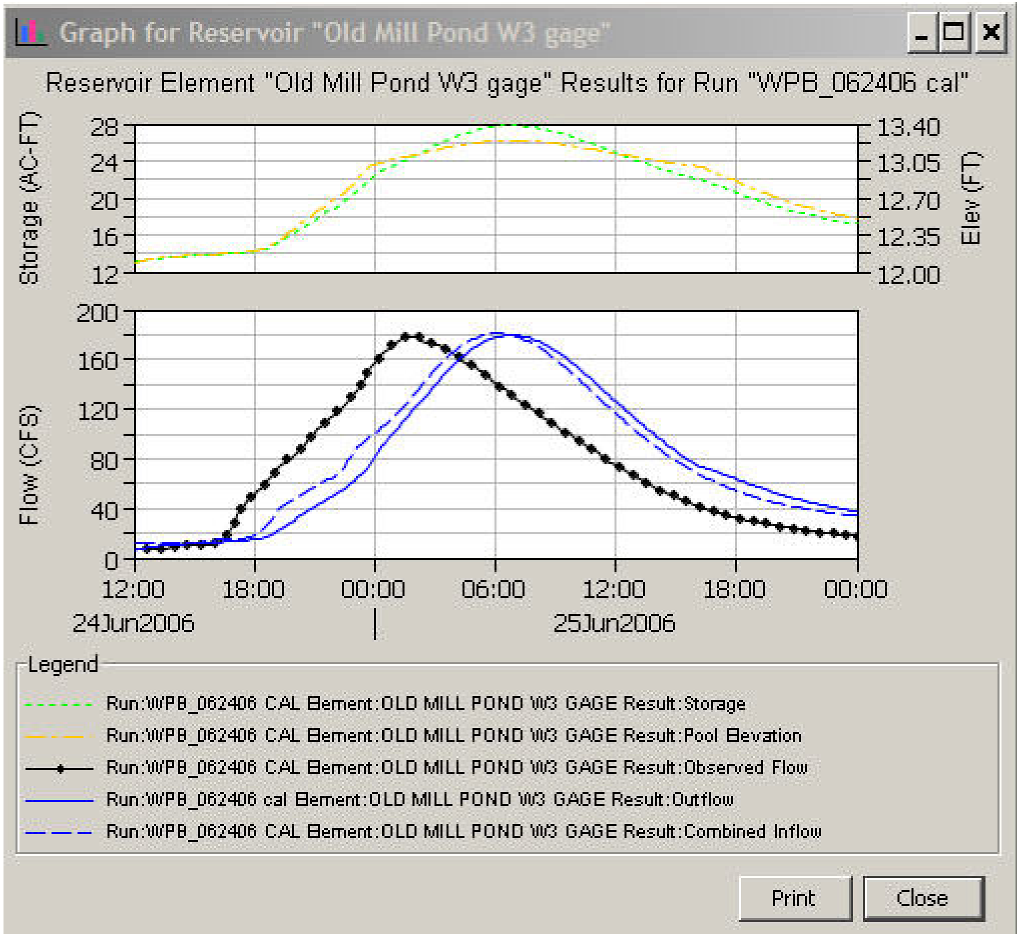


Summary Results for Reservoir "Old Mill Pond W3 gage"

Project: wreck Pond
Simulation Run: WPB_062406 cal Reservoir: Old Mill Pond W3 gage

Start of Run:	24Jun2006, 12:00	Basin Model:	WPBstem_062406 cal
End of Run:	26Jun2006, 00:00	Meteorologic Model:	June24_2006
Compute Time:	03Jun2008, 15:52:55	Control Specifications:	june242006 _wpb stem cal

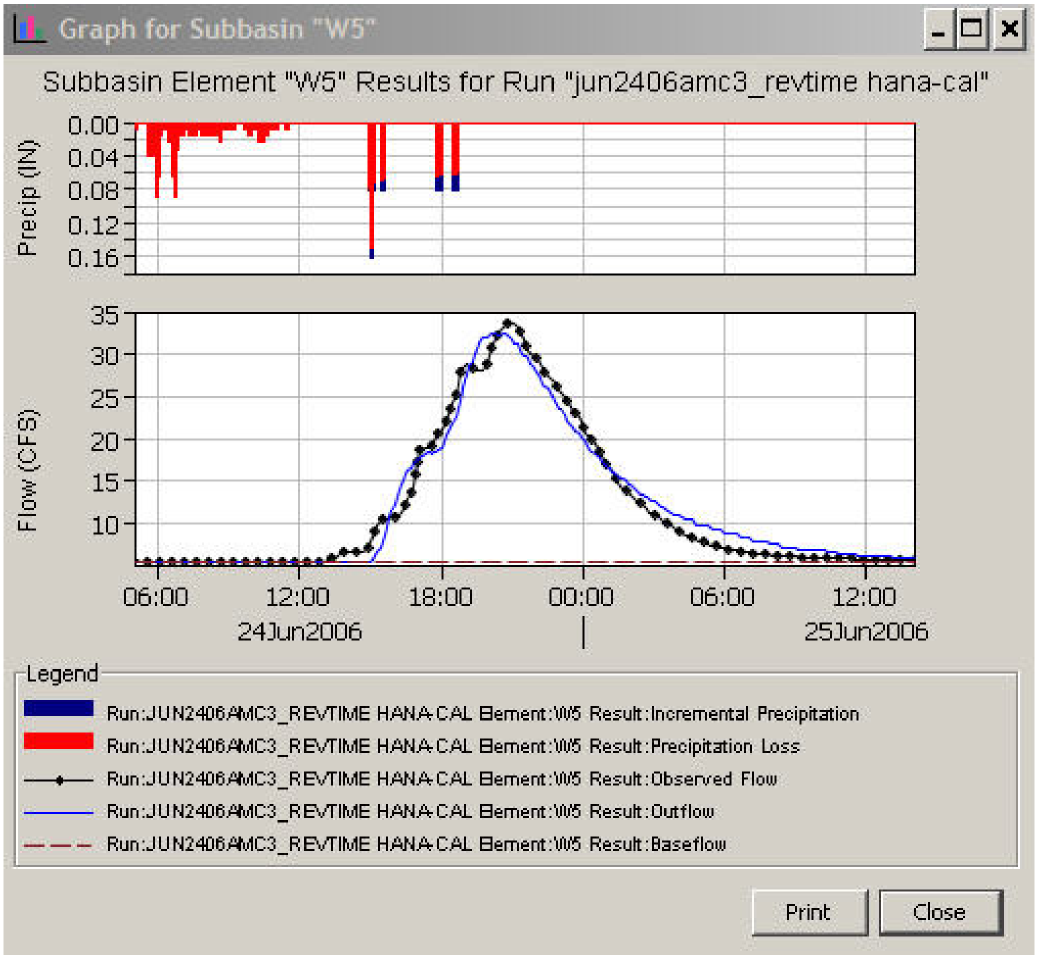
Volume Units: (•) IN ( ) AC-FT

Computed Results

Peak Inflow :	180.9 (CFS)	Date/Time of Peak Inflow :	25Jun2006, 06:10
Peak Outflow :	179.6 (CFS)	Date/Time of Peak Outflow :	25Jun2006, 06:50
Total Inflow :	0.64 (IN)	Peak Storage :	27.8 (AC-FT)
Total Outflow :	0.63 (IN)	Peak Elevation :	13.2 (FT)

Observed Hydrograph at Gage W3 62406

Peak Discharge :	177.50 (CFS)	Date/Time of Peak Discharge :	25Jun2006, 01:30
Avg Abs Residual :	37.04 (CFS)		
Total Residual :	0.03 (IN)	Total Obs Q :	0.59 (IN)



Summary Results for Subbasin "W5"

Project : WPB Hanabrand   Simulation Run : jun2406amc3_revtime hana-cal   Subbasin: W5

Start of Run :	24Jun2006, 05:00	Basin Model :	WPB-Hanabrand June 24 06 cal
End of Run :	25Jun2006, 14:00	Meteorologic Model :	june2406_revised time stamp
Compute Time :	12Jun2008, 10:14:51	Control Specifications :	jun242006

Volume Units : (•) IN ( ) AC-FT

Computed Results

Peak Discharge :	32.6 (CFS)	Date/Time of Peak Discharge :	24Jun2006, 20:12
Total Precipitation :	1.84 (IN)	Total Direct Runoff :	0.13 (IN)
Total Loss :	1.71 (IN)	Total Baseflow :	0.10 (IN)
Total Excess :	0.13 (IN)	Discharge :	0.23 (IN)

Observed Hydrograph at Gage w5 june24 2006

Peak Discharge :	33.79 (CFS)	Date/Time of Peak Discharge :	24Jun2006, 20:54
Avg Abs Residual :	1.07 (CFS)		
Total Residual :	0.00 (IN)	Total Obs Q :	0.22 (IN)

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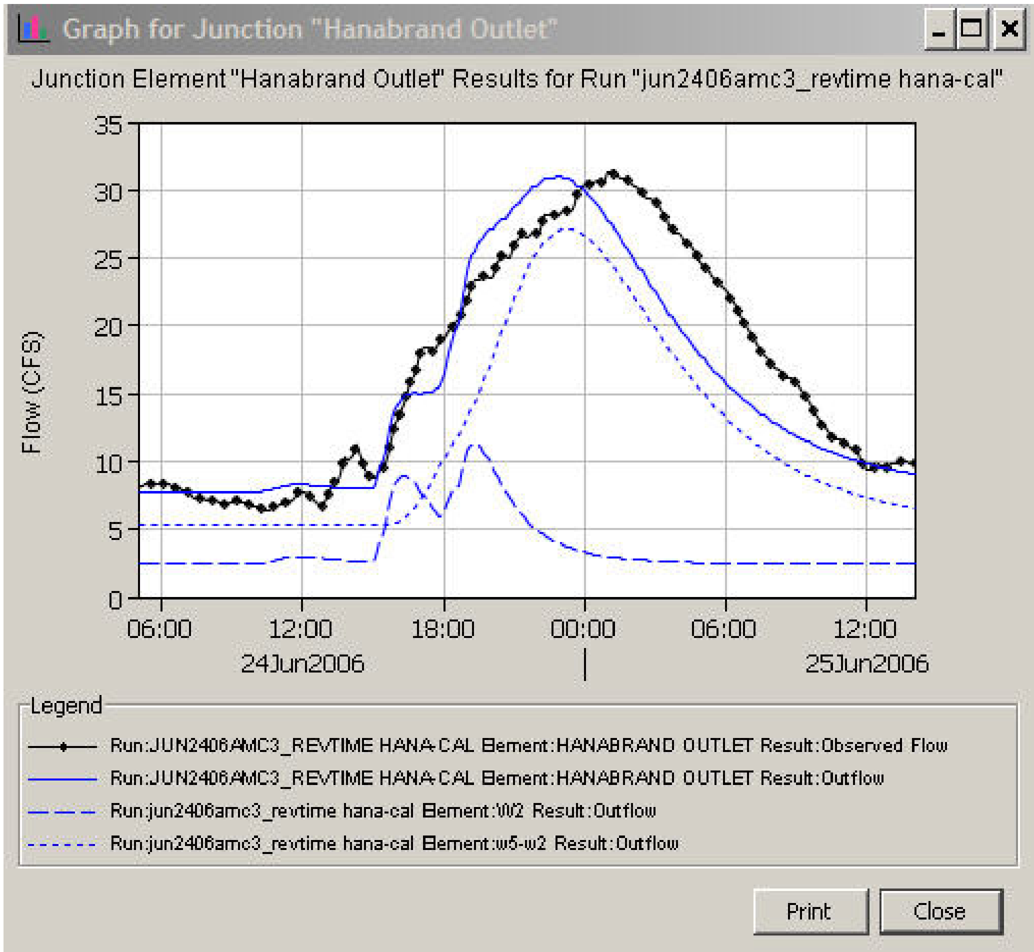

Summary Results for Junction "Hanabrand Outlet"

Project : WPB Hanabrand   Simulation Run : jun2406amc3_revtime hana-cal   Junction: Hanabrand Outlet

Start of Run :	24Jun2006, 05:00	Basin Model :	WPB-Hanabrand June 24 06 cal
End of Run :	25Jun2006, 14:00	Meteorologic Model :	june2406_revised time stamp
Compute Time :	05Jun2008, 15:31:58	Control Specifications :	jun242006

Volume Units : (•) IN ( ) AC-FT

Computed Results

Peak Outflow : 31.0 (CFS)   Date/Time of Peak Outflow : 24Jun2006, 22:54
Total Outflow : 0.26 (IN)

Observed Hydrograph at Gage w2+w5 june 24 2006

Peak Discharge : 31.39 (CFS)   Date/Time of Peak Discharge : 25Jun2006, 01:06
Avg Abs Residual : 2.48 (CFS)
Total Residual : -0.02 (IN)   Total Obs Q : 0.28 (IN)

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