HCFCD Discharge Measurement and Rating Curve Program

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Texas Floodplain Management Association
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Outline

• Starting the program
• Mission statement
• Discharge/Flow
• Site selection process
• Stage measurement
• Field practices
• Discharge measurements
• QA/QC discharge measurements
• Rating Shifts
• Stage-discharge rating curves
• Modeled stage/discharge rating curves
Starting the Rating Curve and Discharge Program

Meet with the experts:
- USGS
- LCRA
- Colleagues

- Mission statement
- Write standard operating procedure
- Develop modeled based rating curves
- Identify data gaps (USGS rating curves)
- Site selection
- Station description
- Clear vegetation
- Training
- Equipment
- Software
Mission Statement

Measure discharge at determined gage locations and create and maintain accurate rating curves to be utilized by HCFCD and partners for flood forecasting and calibration of hydrological models.
Discharge (flow) is the volume of water moving down a stream or river per unit of time. We express this in cubic feet per second.

\[ Q = V \times D \times W \]

- \( Q \) = Discharge
- \( V \) = Velocity
- \( D \) = Depth of water
- \( W \) = Width

1 cubic foot water = 7.48 gallons and weighs 62.42lbs.
Rating curves are determined by taking discharge measurements at different stages.
South Mayde Creek @ Greenhouse Road 5-26-2014

- Base flow at 4:00 pm 96.50 ft.
- Bank full at 5:00 pm 108.00 ft.
- Peaked at 6:30 pm 109.00 ft.
- Rate of rise from 4:00 to 5:00 approximately 0.20 ft. per minute
Site Selection

HARRIS COUNTY FLOOD CONTROL DISTRICT
RAIN AND STREAM GAGE LOCATIONS
as of July 14, 2015

65 HCFCD potential rated locations
40 USGS rated locations
Site Selection

• Better location means better data
• Flow should be relatively uniform and free of eddies, slack water, and excessive turbulence
• Minimal vegetation
• Tidally influenced
Stage Measurement

- Tied to NAVD 88, 2001 adj.
- Accurate stage is the basis for a proper stage-discharge relationship
- Measure stage before and after the discharge measurement
Field Practices

- Use the appropriate equipment
- Standard practices
- Understand channel characteristics
- Control (permanent/temporary)
- Gage height of zero flow (GZF)
- Breakpoint
- Maintain cross section (vegetation, rocks, debris).
HOW the Equipment Works

- The Doppler effect is the change in a sound's observed pitch (frequency) caused by the relative velocities of the sound source and receiver.
- ADCPs take advantage of the Doppler shift to measure the speed of the particles in the water.
Acoustic Digital Current Meter (ADC)

- 6Mhz acoustic frequency
- 2-beam ADCP
- Integrated depth sensor
- Handheld recorder/interface
Measurement Review

Discharge Measurement Summary

**ALABONSON_WHITEOAK**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Station Nr.</strong></td>
<td>540</td>
</tr>
<tr>
<td><strong>Date/Time</strong></td>
<td>11/06/2013 11:17:23 - 12:15:21</td>
</tr>
<tr>
<td><strong>Instrument</strong></td>
<td>ADC</td>
</tr>
<tr>
<td><strong>Units</strong></td>
<td>Imperial</td>
</tr>
<tr>
<td><strong>Measurement method</strong></td>
<td>1 Point</td>
</tr>
<tr>
<td><strong>Averaging time</strong></td>
<td>40 Seconds</td>
</tr>
<tr>
<td><strong>Start edge</strong></td>
<td>RIGHT</td>
</tr>
<tr>
<td><strong>Mean depth(ft)</strong></td>
<td>0.865</td>
</tr>
<tr>
<td><strong>Nr. of verticals</strong></td>
<td>27</td>
</tr>
<tr>
<td><strong>Area(ft²)</strong></td>
<td>137.259</td>
</tr>
<tr>
<td><strong>Discharge(ft³/s)</strong></td>
<td>20.0669 - 0.31</td>
</tr>
<tr>
<td><strong>Operator</strong></td>
<td>JJ</td>
</tr>
<tr>
<td><strong>Software version</strong></td>
<td>2.16</td>
</tr>
<tr>
<td><strong>Sensor Offset</strong></td>
<td>0.10</td>
</tr>
</tbody>
</table>

**Uncertainty According to ISO 748**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall</strong></td>
<td>3.4 %</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td>1.0 %</td>
</tr>
<tr>
<td><strong>Velocity</strong></td>
<td>1.5 %</td>
</tr>
<tr>
<td><strong>Method</strong></td>
<td>2.0 %</td>
</tr>
<tr>
<td><strong>Depth</strong></td>
<td>0.2 %</td>
</tr>
<tr>
<td><strong>Width</strong></td>
<td>0.1 %</td>
</tr>
<tr>
<td><strong>Nr. of Verticals</strong></td>
<td>2.0 %</td>
</tr>
</tbody>
</table>

**Depth Sensor**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Depth Calibration (mBar)</strong></td>
<td>1017.0</td>
</tr>
<tr>
<td><strong>Calibration Date / Time</strong></td>
<td>11/06/2013 11:46:21</td>
</tr>
</tbody>
</table>

**Quality Threshold Settings**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max. % Discharge per Vertical</strong></td>
<td>5</td>
</tr>
<tr>
<td><strong>Min. Correlation (%)</strong></td>
<td>40</td>
</tr>
<tr>
<td><strong>Max. Flow Angle(°)</strong></td>
<td>20.0</td>
</tr>
<tr>
<td><strong>Min. SNR (dB)</strong></td>
<td>10.0</td>
</tr>
<tr>
<td><strong>Max. Single Point Depth</strong></td>
<td>1.50</td>
</tr>
<tr>
<td><strong>Max. Standard Deviation</strong></td>
<td>0.10</td>
</tr>
</tbody>
</table>

WALTER P. MOORE
Acoustic Doppler Current Profiler (ADCP)

- Measuring range 0.65’ – 82.00’
- Auto adapting 1200kHz / 600kHz frequency
HOW ADCP Works
Velocity Graph for Greens Bayou at E. Mt Houston
Measured on 10-31-2015
ADCP Results

- Measurements +/- 5% current rating are re-measured
Rating the Measurement

Measurement rating is based on uncertainty.

- Variability of transect discharges
- Pattern in transect discharges
- Accuracy and % of unmeasured areas
  - top and bottom extrapolation
  - edge extrapolation
- Quantity and distribution of missing/invalid data
- Quality of boat navigation reference
- Bias or noise in bottom track
- Noise in GPS data

Excellent 2%
Good 5%
Fair 8%
Poor >8%
Discharge measurements are used to develop rating curves.

- **Rating Curve**
- **Discharge Measurements**
Discharge Measurements

To maintain ratings, discharge must be measured regularly.

For example: rating changes as channel fills.
Data Storage and Rating Curve Editor

- Daily import of latest USGS rating curves
- Real time USGS flow data
- Real time HCFCD stage & precipitation data
- Stores all field discharge measurements
- Stores HCFCD modeled rating curves
- Rating curve editor
- Share hydrological data
Rating Curves

- Stage/Discharge Rating Curve is the relationship between water level (stage) and volumetric rate of flow (discharge).
Rating Shifts

Ratings are constantly changing. It is the job of the Hydrographer to identify why. Natural streams are most susceptible to these changes.

- High vegetation in summer
- Low vegetation in winter
- Recent flood?
- Type of soil (sandy bottom more susceptible to shifts)
- Control moved
- Upstream development
- Channel modification projects
Rating Shifts

Greens Bayou at East Mt. Houston Winter Versus Summer
Rating Shifts

Add Sim bayou pic. Before and after construction
Development of Initial Rating Curves

Gage 1160: K100 @ Grant Road

Downstream HEC-RAS Bridge Section
Development of Initial Rating Curves

Legend:
- WSS 125%
- WSS 120%
- WSS 115%
- WSS 110%
- WSS 105%
- WSS 100%
- WSS 95%
- WSS 90%
- WSS 85%
- WSS 80%
- WSS 75%
- WSS 70%
- WSS 65%
- WSS 60%
- WSS 55%
- WSS 50%
- WSS 45%
- WSS 40%
- WSS 35%
- WSS 30%
- WSS 25%
- WSS 20%
- WSS 15%
- WSS 10%
- WSS 5%
- WSS 0%
- Ground

Downstream HEC-RAS Bridge Section
Recognized Issues with Initial Rating Curves

- Falling Limb of Hydrograph
- Rising Limb of Hydrograph
Structural Inventory Data

Gage Location

Lowest slab @ 000

"Flood Divide"

Gage 000

"Lowest Slab"

Gage 005

Lowest slab @ 005

100-Year WSEL

Depth A

Depth B

Flowline

Ground
Initial Rating Curve Format

**FWS STATION 1170**
K100 Cypress Creek @ Huffmeister Rd.

<table>
<thead>
<tr>
<th>EVENT DATE</th>
<th>H.W.M ELEV.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/19/1998</td>
<td>131.6</td>
</tr>
<tr>
<td>7/12/2012</td>
<td>130.7</td>
</tr>
<tr>
<td>10/18/1994</td>
<td>130.0</td>
</tr>
<tr>
<td>6/9/2001</td>
<td>129.8</td>
</tr>
<tr>
<td>11/14/1998</td>
<td>129.6</td>
</tr>
<tr>
<td>4/28/2009</td>
<td>129.6</td>
</tr>
<tr>
<td>9/19/1979</td>
<td>128.1</td>
</tr>
<tr>
<td>5/21/1983</td>
<td>127.4</td>
</tr>
<tr>
<td>1/19/1979</td>
<td>123.5</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>ELEV.</th>
<th>DISCHARGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2%</td>
<td>133.7</td>
<td>11337</td>
</tr>
<tr>
<td>1%</td>
<td>131.4</td>
<td>7153</td>
</tr>
<tr>
<td>2%</td>
<td>130.4</td>
<td>5620</td>
</tr>
<tr>
<td>10%</td>
<td>128.4</td>
<td>3417</td>
</tr>
<tr>
<td>TOB</td>
<td>127.2</td>
<td></td>
</tr>
<tr>
<td>FLOWLINE</td>
<td>111.96</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
- High Water Mark elevations are based on survey data. Rating curve from HEC-RAS data.
- Stage at which slab flooding begins to occur
- Suspect elevation, low confidence in field

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**STRUCTURAL INVENTORY (2011)**

<table>
<thead>
<tr>
<th># of STR.</th>
<th>ELEV (ft)</th>
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</thead>
<tbody>
<tr>
<td>1% WSEL</td>
<td>131.4</td>
</tr>
<tr>
<td>3' &gt; L.S.</td>
<td>126.97</td>
</tr>
<tr>
<td>2' &gt; L.S.</td>
<td>125.97</td>
</tr>
<tr>
<td>1' &gt; L.S.</td>
<td>124.97</td>
</tr>
</tbody>
</table>

**LOWEST SLAB**

<table>
<thead>
<tr>
<th>EVENT DATE</th>
<th>H.W.M ELEV.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/12/2012</td>
<td>130.7</td>
</tr>
<tr>
<td>10/19/1998</td>
<td>131.6</td>
</tr>
</tbody>
</table>

**NOTES:**
- DATA FROM HEC-RAS
- CROSS-SECTION # 151153
- TOP OF BANK from HCFCD

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**WALTER P. MOORE**