High-Water Marks Training

Colorado Silver Jackets
Advanced Floodplain Management Workshop

February 12 and 14, 2020

U.S. Geological Survey
Colorado Water Science Center
Mike Kohn, P.E.
HWM Training Outline

• What are HWMs
• What do we do with HWMs
• How do we find HWMs
• How do we mark HWMs
• How do we document HWMs
What are HWMs

• High-water marks are “post-flood evidence that marks the highest elevation of floodwaters”
  – Physical remnants or indications left behind by the flood
What are HWMs
What are HWMs

• High-water marks are often perishable and vulnerable to being degraded or lost as time passes
  – Exposure to elements
  – Cleanup efforts
  – Vegetation growth
What are HWMs

- High-water marks are often perishable and vulnerable to being degraded or lost as time passes
  - Multiple peaks may create misleading secondary HWMs
Why Collect HWMs

• Documentation of high-flow events can help to inform
  – Flood damage estimates
  – Emergency response plans
  – Land management policies
  – Flood mitigation decisions
  – Designs of roadways, bridges, levees, and other infrastructure
Why Collect HWMs

- Calibration and verification of hydraulic models
Why Collect HWMs

- Creation of flood inundation maps and ground-truthing of satellite imagery
Why Collect HWMs

- Indirect measurement of discharge computations
Why Collect HWMs

- Materializing and memorializing floods
HWM Resources

- Techniques and Methods 3-A24
  https://pubs.er.usgs.gov/publication/tm3A24

- Field Manual
  https://pubs.er.usgs.gov/publication/ofr20171105
HWMs Getting Started

- When to start flagging - ASAP
  - When accessible and safe
  - Before repairs and cleaning is completed
  - Before weather degrades the marks
  - FEMA mission assignments take time
HWMs Getting Started

- Where to look
  - Look up
  - Stand back
  - Visualize the flood
  - Start at a gage station, local staff plate, or site with known peak
  - Talk to locals but verify with physical marks
TYPES OF HIGH-WATER MARKS
Identifying HWMs
Tranquil-water vs. Rapid-water HWMs
Identifying HWMs

Common tranquil-water HWMs

- Mud lines
- Seed lines
- Debris lines
- Ice rings
Identifying HWMs

Common tranquil-water HWMs

- Mud lines (stain lines)
Identifying HWMs

Common tranquil-water HWMs

- Mud lines (stain lines)
Identifying HWMs

Common tranquil-water HWMs

- Seed lines
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• Seed lines
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Identifying HWMs

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• Debris lines
Identifying HWMs

Common tranquil-water HWMs

- Ice Rings
Identifying HWMs

Common rapid-water HWMs

- Cut lines
- Wash lines
- Mud lines
- Debris snags
Identifying HWMs

Common rapid-water HWMs

- Cut lines
Identifying HWMs

Common rapid-water HWMs

- Cut lines
Identifying HWMs

Common rapid-water HWMs

- Wash lines
Identifying HWMs

Common rapid-water HWMs

- Wash lines
Identifying HWMs

Common rapid-water HWMs

• Wash lines
Identifying HWMs

Common rapid-water HWMs

• Mud lines
Identifying HWMs

Common rapid-water HWMs

• Debris snags
Identifying HWMs

Common rapid-water HWMs

- Debris snags
Identifying HWMs

Common rapid-water HWMs

- Debris snags
Identifying HWMs
Engineered high-water marks
Considerations and Common Pitfalls

- Safety first
- Respond quickly
- Look up
- Try to picture the flood
- Secondary or previous events. Have some idea of past floods so you do not mistake old HWM with new.
- Should have more than one HWM at a site
- A site is an area where HWM elevations should be the same
- When in doubt, collect more data
Considerations and Common Pitfalls

- **Recession marks**
  - Debris lines that don’t represent the peak
- **Stability of HWM structure**
  - Flimsy trees
  - Large objects could have been displaced by floodwaters, shifted during recession, or moved during cleanup
- **Proper identification of water-borne particles**
  - Debris could have been deposited by other means
  - Particularly difficult with weathered HWMs
- **Elevation of marks on slopes can change because of slumping**
- **Land owners are a good starting point, but may not have seen the actual peak**
- **An excellent mark could may not represent the peak in question**
- **Structures can alter HWMs**
  - Drawdown at bridges
  - Enclosed buildings
PRESERVING HIGH-WATER MARKS
Preserving HWM data

• Evaluation
• Marking and flagging
• Recording

<table>
<thead>
<tr>
<th>Amount of vertical uncertainty</th>
<th>Shorthand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within ±0.05 foot</td>
<td>Excellent (E)</td>
</tr>
<tr>
<td>Within ±0.10 foot</td>
<td>Good (G)</td>
</tr>
<tr>
<td>Within ±0.20 foot</td>
<td>Fair (F)</td>
</tr>
<tr>
<td>Within ±0.40 foot</td>
<td>Poor (P)</td>
</tr>
<tr>
<td>More than ±0.40 foot</td>
<td>Very poor (V)</td>
</tr>
</tbody>
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High-water mark defines the minimum height of the peak, but peak may have been higher to an unknown extent.
Preserving HWM data

• Evaluation
  – each high-water mark should be evaluated based on the vertical range (uncertainty) of peak surfaces that could be described by the evidence.
Preserving HWM data

• Evaluation
  – Example 1
  • A well-defined seed line is likely to have a smaller uncertainty, such as within ±0.05 ft, Excellent (E)
  • The line is on an outside structure (good hydraulic connectivity) and is consistent and straight with no seeds above the line.
Preserving HWM data

• Evaluation
  – Example 2
  • cut line shown below might be assigned an uncertainty value of “±0.3 foot” if such a range adequately accounted for slumping.
Preserving HWM data

• Evaluation
  – Example 3
    • Debris line shown below might be assigned an uncertainty value of “±0.15 foot” because of the curves in debris line.
Preserving HWM data

- **Evaluation**
  - **Example 4**
    - Debris line on the back of the fence, a reasonable uncertainty for an HWM might be about ±0.2 ft, which is half the distance between the highest row of wire junctions that holds debris and the next highest row of junctions holding no debris.

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<tr>
<td>High-water mark defines the minimum height of the peak, but peak may have been higher to an unknown extent.</td>
<td>At least this high (ALTH)</td>
</tr>
</tbody>
</table>
Preserving HWM data

• Marking and Flagging
  – nails
  – stakes
  – survey flagging tape
  – wire flags
  – marking tabs
  – paint line (using a straight edge)
  – permanent ink markers
  – chiseled marks

Complete list on Page 32 of HWM T&M 3-A24
Preserving HWM data

• Marking and Flagging
  – Because HWMs should be flagged as quickly as possible after a flood, separate field crews will commonly flag and later survey the HWMs
  
  – Assume the mark itself will be gone by the time the surveyor gets there
    
  – Field crews should obtain permission from landowners before placing permanent or semi permanent markings on private property.
Preserving HWM data

• Marking and Flagging
  – Marks can even be “moved” to more easily surveyed points if done carefully.
Preserving HWM data

• Marking and Flagging
  – In most cases, survey flagging should be included with the mark and annotated with the date, uncertainty, and unique identifier for the high-water mark.
  – Common naming convention: “ID-x-u” where:
    • “ID” is the unique name for group of HWMs at a site.
    • “x” is a unique identifying number assigned to each mark
    • “u” is the uncertainty.
Preserving HWM data

• Recording
  – Notes, photographs, and video of high-water marks will ensure that useful data about the marks are available weeks or years after the search is complete.
  – These records help field crews locate the flagged high-water marks if the survey is completed at a later date and provide a permanent record if the accuracy or application require further analysis.
Preserving HWM data

• Recording

Typical field notes include:
– Site sketch or electronic map with all HWMs noted
– Wide angle photographs
– unique identifier
– the type of mark (for example, seed line or debris snag)
– the uncertainty of the mark
– the approximate location
– any comments or observations about landowners, hazards, or nearby landmarks.
– Handheld GPS collected location data
Preserving HWM data

More pictures the better!

1. Close up that shows the type of HWM
2. Wide zoom picture with something in the background for reference
3. Picture measuring height above ground
4. How it was marked and site information
### Site Visit Summary

<table>
<thead>
<tr>
<th>STATION ID:</th>
<th>STATION NAME:</th>
<th>WATERBODY:</th>
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<tbody>
<tr>
<td></td>
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<table>
<thead>
<tr>
<th>LAND OWNER:</th>
<th>EMAIL:</th>
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<table>
<thead>
<tr>
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<th>COUNTY:</th>
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<tbody>
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<table>
<thead>
<tr>
<th>Party:</th>
<th>Start Time (UTC):</th>
<th>End Time (UTC):</th>
<th>Weather:</th>
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<tbody>
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</table>

#### Site Visit Tasks

- [ ] Navigating HWMs only
- [ ] Retrieving Navigated HWMs
- [ ] Levels
- [ ] Dates
- [ ] Pictures taken
- [ ] Site sketch

#### Datum

<table>
<thead>
<tr>
<th>Horizontal datum:</th>
<th>How was it determined:</th>
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</table>

<table>
<thead>
<tr>
<th>Vertical datum:</th>
<th>How was it determined:</th>
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</table>

Type of "on-site" Objective Point used to determine HWM elevation: [ ] Elevations

Name (if NRMM): [ ] ID: [ ] DES: [ ] Description: [ ]

#### High Water Mark

**HWM Elevation:** (+/-) [ ]

<table>
<thead>
<tr>
<th>Type:</th>
<th>Location (left/right):</th>
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</tbody>
</table>

How was elevation determined: [ ]

How was elevation determined: [ ]

Comments: [ ]

Marked: [ ]

Transmit/Sellwater HWM: [ ] YES [ ] NO

HWM Description: [ ]

Height above ground: [ ] Date Plugged: [ ] Date Surveyed: [ ]

Comments: [ ]

### Site Sketch

Import Image Here
USGS Flood Event Viewer

- https://stn.wim.usgs.gov/fev/
or search for “USGS Flood Event Viewer”

USGS Colorado Flood Database

  or search for “USGS Colorado Flood Database”
Questions?

U.S. Geological Survey
Colorado Water Science Center
https://www.usgs.gov/centers/co-water

Mike Kohn, P.E.
(303)236-6924
mkohn@usgs.gov