Hazard Mitigation Technical Assistance Program
Contract No. EMW-2000-CO-0247
**Task Orders 276 and 279**
**Hurricane Isabel Rapid Response**
**Coastal High Water Mark (CHWM) Collection**
FEMA-1492-DR-MD

# Final Report

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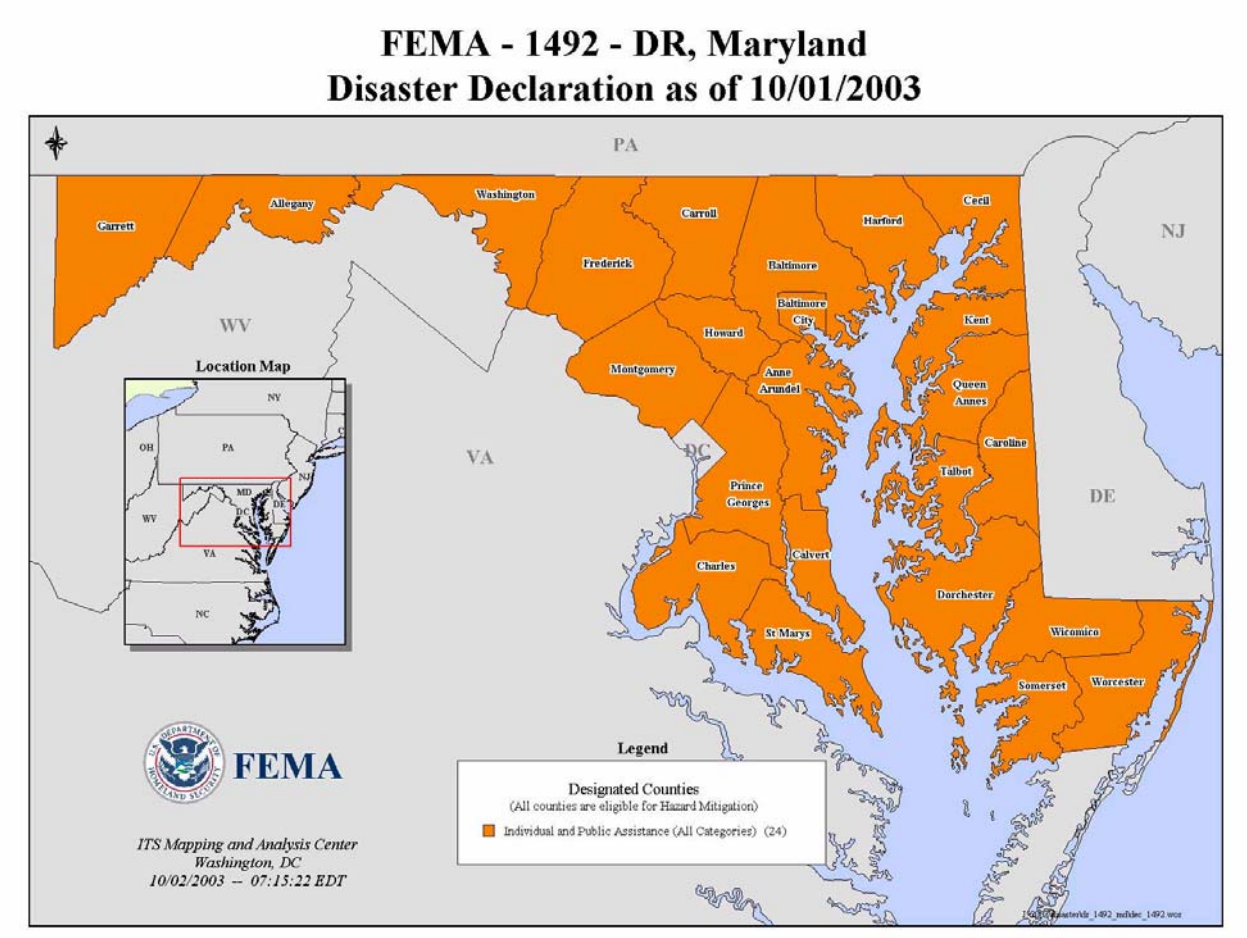
# Introduction

On September 18, 2003, Hurricane Isabel made landfall on the North Carolina coast between Wilmington, North Carolina and Norfolk, Virginia. As the hurricane moved northwest through Virginia, Maryland, and DC, wind and wave action along the Chesapeake Bay in Maryland disrupted power and communication lines and caused localized flooding. The hurricane caused significant wind and flood damages along the upper Chesapeake Bay within the State of Maryland.

A disaster declaration in response to Hurricane Isabel was authorized by the Federal Emergency Management Agency (FEMA) for Maryland on September 19, 2003. As stated by the Maryland Governor, Robert L. Ehrlich, "This sorely-needed disaster declaration will help citizens and businesses alike with damage assessment, repair, insurance, and other critical recovery measures." The declaration provides the necessary assistance to meet immediate needs and to help Maryland get back on the road to recovery as fast as possible. All counties in Maryland were designated for disaster declaration, as shown in Figure 1. The assistance will help these Counties.

**Figure 1: Disaster Declaration Map**




URS Group, Inc. was contracted by FEMA under the Hazard Mitigation Technical Assistance Program (HMTAP) to assist in the disaster recovery. Part of this assistance included the collection and survey of High Water Marks (HWMs). This report summarizes the methodologies used to collect the HWM

locations and elevations established during the Hurricane in Maryland and Washington, DC. This is an important step in assisting communities in establishing flood hazard areas and to prevent future loss of life and property damage.

Hurricane Isabel caused both coastal and riverine flooding. The resulting HWMs were flagged and surveyed along coastal locations. The purpose of this report is to document the flagging and surveying of Coastal High Water Marks (CHWMs), provide an estimation of the storm surge at each location, and document the orientation to the assumed storm surge and wave action.

The data collected is invaluable to federal, state, and local recovery efforts. The data assists in identifying areas of significant damage in order to target resources needed for disaster recovery. It also helps to establish the magnitude and recurrence interval of the flood and erosion events caused by the hurricane along various areas of the coast. This data collection is also beneficial in (a) accurately assessing the benefits to be expected from flood mitigation efforts and (b) prioritizing the flood mitigation efforts pursued following the hurricane.

# Area of Study

The initial review of the coastal counties and cities was completed on September 25, 2003. The review began with a meeting with FEMA Disaster Field Office (DFO) officials on September 24, 2003 and followed with a definition of the scope and location of desired CHWMs.

Further analysis, utilizing field investigations, various GIS support coverages, and local media reports, was performed to determine additional CHWM collection areas. In summary, CHWMs were recommended and surveyed in 13 counties and the District of Columbia as shown in Table 1.

**Table 1: Number of CHWMs Investigated by County/Area**

| County | Number of CHWMs Surveyed |
|---|---|
| Anne Arundel County | 49 |
| Baltimore County | 34 |
| Calvert County | 12 |
| Cecil County | 3 |
| Charles County | 5 |
| Dorchester County | 5 |
| Harford County | 8 |
| Kent County | 8 |
| Prince George's County | 5 |
| Queen Anne's County | 9 |
| Somerset County | 2 |
| St. Mary's County | 12 |
| Talbot County | 6 |
| Washington, D.C. | 1 |

According to the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) Center for Operational Oceanographic Products and Services, the highest storm tides occurred in Baltimore. Table 2 is a summary of NOAA NWS tidal gage peak readings during Hurricane Isabel on September 19, 2003. The foldout map in the pocket of this report includes these tidal stations along with the points surveyed in the 14 counties and Washington, D.C.

**Table 2: NOAA NWS Tidal Gage Stations on Chesapeake Bay and Peak Readings during Hurricane Isabel**

| | | | | Hurricane Isabel Peak Elevation (ft) | |
|---|---|---|---|---|---|
| Station ID: | Name | Longitude (West) | Latitude (North) | (MSL) | (NAVD 88) |
| 8571892 | Cambridge, Choptank River | 76 deg 04.1 min | 38 deg 34.4 min | 5.16 | Not available |
| 8594900 | Washington, Potomac River | 77 deg 01.3 min | 38 deg 52.4 min | 5.84 | 5.793 |
| 8635150 | Colonial Beach, Potomac River Virginia | 76 deg 57.6 min | 38 deg 15.1 min | 4.45 | 4.458 |
| 8635750 | Lewisetta, Potomac River Virginia | 76 deg 27.9 min | 37 deg 59.7 min | 3.01 | 3.033 |
| 8573927 | Chesapeake City, Md | 75 deg 48.6 min | 39 deg 31.6 min | 4.05 | 4.063 |
| 8573364 | Tolchester Beach, Chesapeake Bay Maryland | 76 deg 14.7 min | 39 deg 12.8 min | 7.07 | |
| 8574680 | Baltimore, Fort McHenry, Patapsco River Maryland | 76 deg 34.7 min | 39 deg 16.0 min | 7.35 | 7.360 |
| 8575512 | U.S. Naval Academy, Severn R., Ches. Bay Maryland | 76 deg 28.8 min | 38 deg 59.0 min | 6.48 | 6.496 |
| 8577330 | Solomons Island, Patuxent River Maryland | 76 deg 27.1 min | 38 deg 19.0 min | 3.7 | 3.729 |

# Marking and Survey Methodology

Field and survey crews from URS, Greenhorne and O'Mara, and Dewberry were deployed to conduct resident interviews, take digital photos and survey CHWMs from Hurricane Isabel.

Based on locations developed and identified by FEMA and the State of Maryland as areas of highest priority for CHWM collection, field crews were dispatched in designated areas to perform reconnaissance of the affected areas and flagging of CHWMs using available information from preliminary damage reporting, coastal flood stage data, and interviews with flooded residents and witnesses. Field crews identified areas of concern, based on general guidelines for HWM spacing (approximately 1 CHWM per mile of affected shoreline), used hand-held GPS units to document the locations of the CHWMs, completed a Historical Flooding Survey Form (Figure 2), and flagged the CHWM. In some cases, witnesses were interviewed and they pointed out the highest water surface reached by the storm surge or coastal stillwater on an object such as a building, mailbox, or telephone pole. Additionally, the locations of debris lines along the ground were inventoried as CHWMs. Debris lines are as much an indication of high water as a mudline on a building and the Professional Licensed Surveyor (PLS) was able to certify a debris line as well as they were able to certify a mud line. The PLS certification is for a point identified by a flagger, the flagger determined the point of high water.

**Figure 2: Sample Historical Flooding Survey Form**

**HIGH WATER MARK (HWM) REPORT**

| | |
|---|---|
| Site ID | |
| Stream Name | |
| Unit Number | |
| Name of Crew | |
| Company | |
| Date of flagging | |
| Address of HWM | |
| Description of Mark | |
| Vertical Distance from set point | |
| HWM Object | |
| Type of Mark | |
| Type of HWM | |
| HWM Quality | |
| Coastal Flood Type | |
| City | |
| County | |
| State | Maryland |
| Witness Information: | Name:<br>Address:<br>Telephone Number |

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| | |
|---|---|
| Photo ID | |
| Photo Orientation | |
| Photo description | |
| Flagger HWM latitude | |
| Flagger HWM Longitude | |
| Comments | |

Plan View

Elevation View

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Field crews noted CHWMs with characteristics such as Surge, Wave Runup, and Wave Height. These designations on the survey sheets in the Appendices represent the flagger's estimate of this characteristic based on a combination of physical flood evidence and interviews with witnesses at the time of collection.

Surge represents the rise in the normal water level, wave runup indicates the height of water rise above the still-water level due to water rush up from a breaking wave, and wave height indicates CHWM elevation due to more direct wave action. Typically, Surge CHWMs are associated with a slow rising flood that causes more water damage than structural damage. Wave Height usually results in a higher elevation. All attempts were made to flag storm surge elevations, but in areas where Surge characteristics were not obvious, Wave Runup or Wave Height were flagged. In some cases, witnesses might claim the flooding was associated with a storm surge when in fact the flooding was from wave run up or riverine flooding.

GPS survey crews followed the field crews and used static GPS methods to determine an accurate elevation for each CHWM. Since static GPS requires an area with no tree cover to return an accurate result, in some cases it was necessary perform a short level loop survey from the GPS point to the CHWM. Wherever possible, the finished floor elevation of structures adjacent to the CHWM was collected. This information may be used at a later date for possible damage assessments or Hazard Mitigation Grant Program applications. CHWM locations were surveyed horizontally in NAD 83, State Plane feet, and vertically in NAVD 88 US survey feet. CHWM locations have been surveyed to within accuracies of 0.25 feet vertically and 10 feet horizontally with a 95% confidence level.

# Findings and Observations

In general, Hurricane Isabel produced more extensive flooding from storm surge and coastal stillwater flooding than from riverine flooding from heavy rains as the storm moved inland. Excessive damage was witnessed in many communities located along the Chesapeake Bay and coastlines on inland waterways. Many structures were destroyed as a result of the storm surge. Despite widespread power outages and lack of water in most coastal communities, field crews did not encounter any significant constraints to access. Figures 3 and 4 below are photos of 2 CHWMs collected after Hurricane Isabel.


**Figure 3: CHWM in Baltimore County**

**Figure 4: CHWM in Harford County**

Because of the level of activity following a storm of Isabel's magnitude, including the demolition of condemned structures and the cleaning of personal property, field crews had to spend more time locating CHWMs that had not been disrupted by the actions of residents or weather conditions.

In some of the communities that were identified for surveying of CHWMs, no evidence of flooding was witnessed. For these areas, field crews marked a location and noted that there was no flooding.

Some surveyed CHWM elevations are outliers to the average CHWM elevations surveyed in an area. Some of these outliers are due to the poor quality of the mark and the flaggers probable interpretation of wave action as storm surge (for an outlier higher than average) or weather or cleanup activities eliminating the upper portions of a mark causing a flag to be placed at a lower than average elevation. Still others may be due to eyewitness attempting to recall an actual HWM. When appropriate, these outliers are identified in the individual survey sheets in the Appendices.

Some of the photographs on the individual survey sheets in the Appendices is difficult to interpret due to either the cameras or the lighting conditions at the time the pictures were taken (i.e., low light situations). Attempts were made to improve those pictures but some low quality pictures remain in the report.

A quality/confidence factor was recorded by the flaggers at the time the points were flagged. This data field included on the individual survey sheets in the Appendices. In addition, "N/A" is used occasionally on the individual survey sheets in the Appendices to indicate data or information that is either not available or not applicable.

Hazardous Mitigation Grant Program (HGMP) and repetitive loss structures are identified on the map in the pocket and on the county maps within the Appendices. Where feasible, the flaggers attempted to mark the CHWM on a HGMP or repetitive loss structure so that FEMA can compare CHWM from Hurricane Isabel to previous HWMs.

# Recommendations

The following recommendations discuss how FEMA can utilize the HWM information to assist in the recovery effort from Hurricane Isabel:

- Compare the Isabel HWMs to the flood elevation data on the effective or preliminary Flood Insurance Rate Maps. These comparisons can help FEMA make determinations on where the updated flood hazard data was supported by the flooding that occurred or where new detailed studies should be performed to update the maps, and can help illustrate deficiencies on the existing maps.

- Compare the Isabel HWMs to HWMs from other significant flood events. This will identify areas of repetitive flooding that can assist FEMA in determining locations that would make good buyout areas.

- Complete detail engineering analysis to determine flood elevations in the areas where deficiencies have been identified on the existing FEMA maps, or on areas where property loss occurred where no previous studies have been prepared.

- The locations and severity of the Isabel HWMs can help FEMA identify areas of concern for future mitigation projects when funding for such projects come available.

- Use these HWMs to evaluate the success of completed mitigation projects. The flood depths that occurred during Isabel can be used to estimate potential damage that could have occurred to structures that have been bought out and removed as part of mitigation projects already completed. Documentation of the "damages avoided" can be used as success stories to further support the mitigation efforts.

- The HWMs can be used to create inundation mapping for Hurricane Isabel. The inundation maps would provide a plan view look at the extent of flooding from Hurricane Isabel and can assist in determining the accuracy of existing FEMA flood maps. The inundation mapping would be a spatially correct GIS coverage that can be provided to community officials to assist in disaster recovery.

- Provide this report on the Internet to aid public officials and the community in general in the recovery effort.