FACT SHEET

September 2010

Understanding the River Forecast Process

Middle Atlantic River Forecast Center

Timely flood warnings and accurate river forecasts are critical to saving lives and property. Disaster preparedness decreases property damage by an estimated $1 billion annually nationwide. Flood forecasts may appear routine but their preparation requires the joint efforts of various federal, state and local agencies.

The Middle Atlantic River Forecast Center (MARFC) is one of 13 regional centers operated by the National Weather Service (NWS) which prepares river forecasts. Located in State College, Pa., MARFC's area of responsibility includes the following river basins:

- Susquehanna
- Delaware
- Passaic
- Raritan
- Potomac
- Rappahannock
- James

Middle Atlantic River Forecast Center Region

The Forecast Process

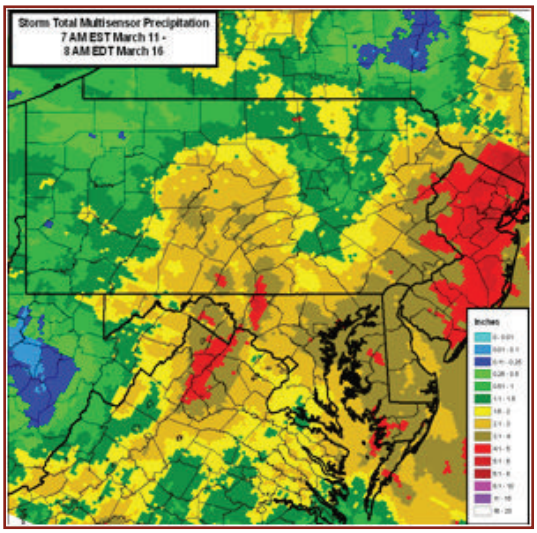
MARFC provides a variety of hydrologic forecasting services. Although flood forecasts are the most well known product, forecast centers also generate river and water information used for navigation, recreation, reservoir operations, and water supply plans. With regard to floods, MARFC prepares hydrologic forecasts for the time and height of flood crests, the time when a river is expected to exceed flood stage, and the time when a river is anticipated to return within its banks. This is critical information for saving lives and reducing property damage during high waters. There are three key steps to preparing and issuing hydrologic forecasts. Those steps are described in this fact sheet.

Step 1: Data Collection

Hydrologic forecasting begins with data collection. MARFC relies upon a variety of data to develop river forecasts. This information comes from the National Weather Service and several cooperating agencies. Types of data that are needed include:

Precipitation -- The amount and location of rainfall that has occurred in the past. Sources of past precipitation are rain gages and RADAR. MARFC has access to data from over a thousand precipitation gages and 13 NWS RADARS. The rain gages are operated by the NWS, U.S. Geological Survey (USGS), U.S. Army Corps of Engineers (USACE), CoCoRaHS, New York City Department of Environmental Protection, and state and county agencies. Gage and RADAR data are merged into a Multisensor Precipitation Estimate of hourly gridded precipitation for all basins (Figure 1).

Figure 1: Hourly Rainfall Totals for MARFC Region



Rainfall Forecasts -- Forecast rainfall has the most impact on river forecasts. MARFC predicts precipitation two days (48 hours) out and updates the forecast every six hours. Differences in the location, intensity or timing of the precipitation can have a significant impact on river levels.

River and Reservoir Levels -- Current river stages and reservoir pool elevations are also important data to collect. In addition, information on reservoir operators' plans to release water into the rivers is taken into account. This river and reservoir information is provided by MARFC's partners, mainly the USGS and the USACE.

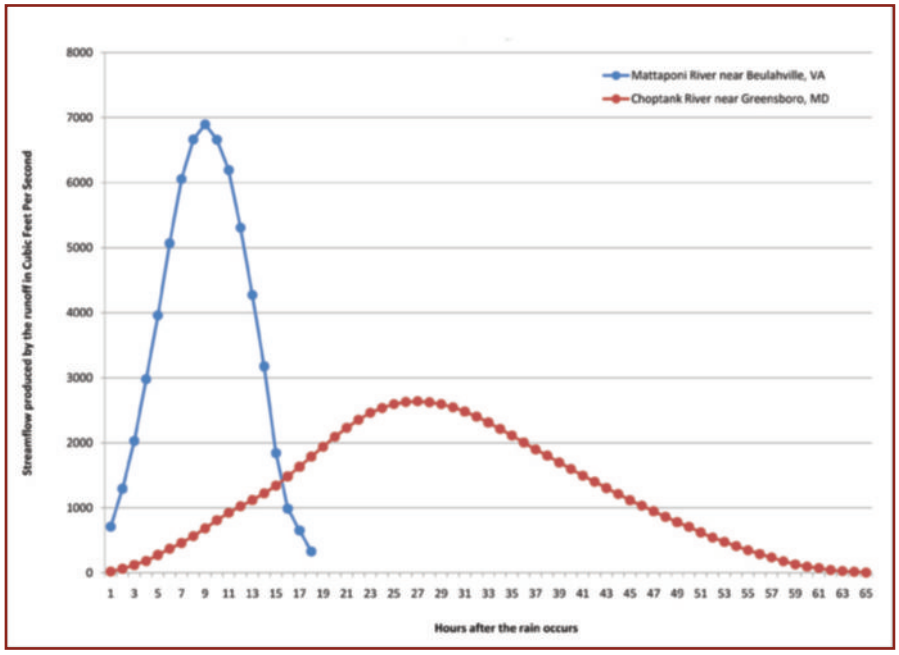
Temperatures – Past and forecast temperatures are needed during the snow season to incorporate snow-melt into the river forecasts.

Step 2: Run Hydrologic Models

When precipitation has occurred, or is forecast to occur, MARFC use a Rainfall-Runoff Model to estimate the amount of runoff that will be produced by the precipitation in a particular basin.

The runoff amounts are calculated for smaller subbasins that send stream flow into larger river systems. For each sub-basin, a Unit Hydrograph is applied to determine the magnitude and timing of the flow at the basin outlet (Figure 2).

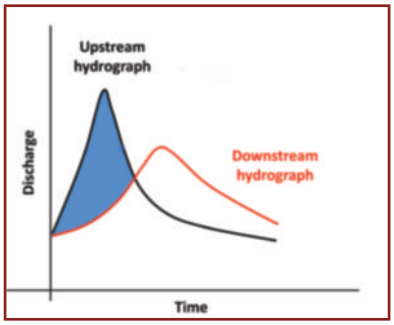
Figure 2: Example of Unit Hydrographs



The Unit Hydrograph is the result from one inch of runoff occurring uniformly over space and time. The shape of the graph is affected by the slope of the terrain, the soil type, and the amount of impervious cover. Mountainous basins and urbanized basins will have hydrographs that peak higher and quicker than they would in flatter terrain or non-urbanized areas.

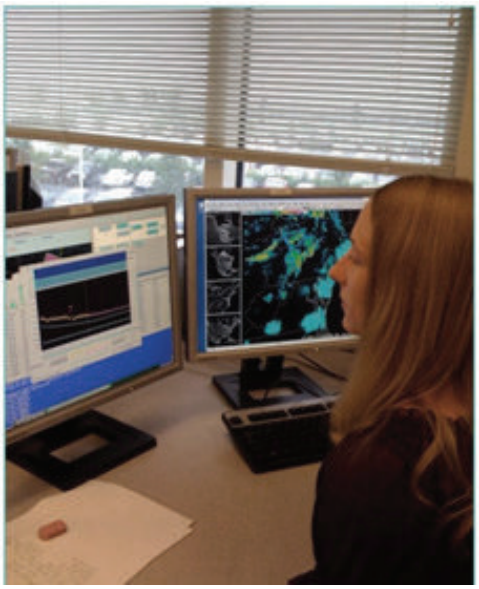
The increased streamflow is treated like a wave traveling down the stream (Figure 3). Forecasters route this wave to downstream points using a Routing Model that attenuates the wave and slows its arrival downstream. This Routing Model takes into account that the waves travel at different speeds depending on the flow.

Figure 3: Routed Flood Wave



The result of these hydrologic models is a forecasted streamflow, expressed in cubic feet per second.

River forecast hydrologists must possess extensive knowledge of the river basin to assure that data used in the models are accurate and reliable. Hydrologists interact with the models to make adjustments to the river simulations to compensate for differences between the observations and assumptions of the models.



Forecast hydrologists apply their professional judgment to sophisticated computer models to produce the most accurate forecast products.

Key River Forecast Terms

The impacts of floods vary from one river location to another because a certain river stage (height) in one location may have an entirely different impact than the same level might have at another location.

The National Weather Service conveys the magnitude of observed or forecast flooding using flood-severity categories. These categories include minor flooding, moderate flooding and major flooding.

Each category has a definition based on property damage and public threat.

- **Minor Flooding**: Minimal or no property damage, but possibly some public threat or inconvenience.
- **Moderate Flooding**: Some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary.
- **Major Flooding**: Extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations.

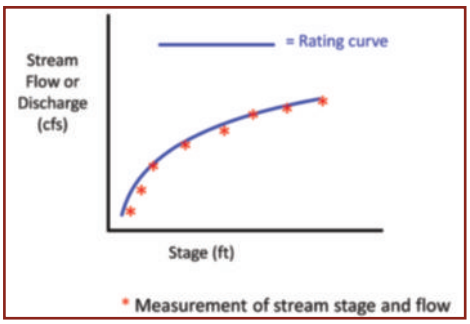
Step 3: Issue River Forecasts

The hydrologist then converts the streamflow to a stage using a rating curve (Figure 4) developed by the USGS through field measurements. A river stage is the height or water depth of a river above an established reference point, commonly measured in feet.

The NWS issues 48- or 72-hour forecasts every morning for locations throughout the Middle Atlantic Region (Figure 5). In high water, forecasts are made available at additional locations.

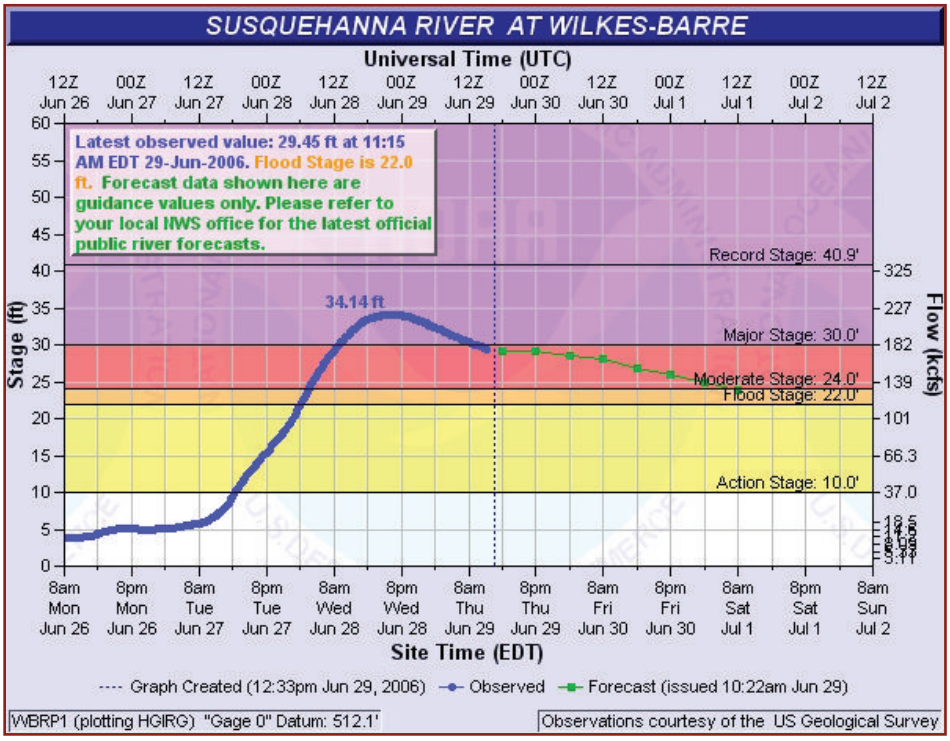
All forecasts are updated as needed, which can be at any time, day or night. To see the current river forecast and the precipitation information used in those forecasts, visit the NWS website at: http://water.weather.gov/ahps (click on the water tab).

Figure 4: Rating Curve



The rating curve depends upon the shape, size, slope and roughness of the channel at the streamgage and is different for every streamgage. As stream channels change due to such factors as erosion or seasonal vegetation, rating curves are adjusted.

Figure 5: River Forecast for Susquehanna River at Wilkes-Barre, PA.



Green dotted line illustrates the forecasted river stage for a future, four-day period.

The Future of River Forecasting

Higher resolution forecast models, probabilistic and ensemble river forecasts, incorporation of tidal effects and new dissemination technologies are all in the works. Inundation mapping has already come to the Mid-Atlantic region – see a list of the locations where this service is available at: http://water.weather.gov/ahps/inundation.php.

How are river forecast points selected?

Why does the NWS issue forecasts for some towns and not others? Several factors go into providing river forecasts:

- The existence of a stream gage at the location.
- A history of data collection at the location.
- Rating Curves developed at many different river flows.
- The river model calibrated for the river response during many different past precipitation events and seasons.
- The size of the basin – too small basins will respond to rain much quicker than current hydrologic models can forecast. These are best served by flash flood arial watches and warnings.
- The community needs forecast information – if the river floods, but does not harm any person or property – forecast services would not be needed.

The most rapid flood events are flash floods, which can develop anytime up to about 6 hours from the time of heavy rainfall. The term flash is used to signify a sense of urgency and indicates that immediate action should be taken to mitigate the impacts of the flood. In contrast, a flood or river flood is any high flow, overflow or inundation by water, which causes or threatens damage. The impacts of both flash and river floods can be devastating.

Forecast Terminology

Urban and Small Stream Advisory – issued when flooding of small streams, streets and low-lying areas, such as railroad underpasses and urban storm drains, is occurring or is imminent. Advisories are issued when such events warrant notification of the public in a product less urgent than a warning.

Flood Watch — issued when flooding is possible – typically within a 6 to 48 hour time frame before the event.

Flood Warning — issued when flooding conditions are actually occurring or are imminent.

Flash Flood Watch — issued when flash flooding is possible. Flash Flood Watches are generally issued for flooding that is expected to occur within 6 hours of the event, which could be heavy rainfall or a dam or levee failure.

Flash Flood Warning — issued when flash flooding is actually occurring or imminent. Flash flood warnings tend to be fairly localized areas such as a county or small group of counties, and the specific locations threatened within those areas are often highlighted. Flash Flood Warnings are issued for short-term events, which require immediate action to protect lives and property, such as dangerous small stream flooding or urban flooding and dam or levee failures.

Flooding is responsible for more fatalities than any other severe weather related phenomena. The average annual deaths attributable to flooding exceed those from lightning or tornadoes. For the 20-year period 1984-2004, floods on average are responsible for $4.6 billion in damage and more than 100 deaths. Unfortunately, more than half of all flood-related deaths result from vehicles, including pickup trucks and SUVs, being swept away by water covering roads.

Learn More

To learn more about hydrology, there are free online training modules available from The COMET Program at http://www.meted.ucar.edu/.

Get Involved

Precipitation measurements are always needed for the NWS river forecast process. If you are interested in sending us your rainfall observations, check out the volunteer program "CoCoRaHS", the Community Collaborative Rain, Hail and Snow Network. *Photo Credit: Henry Reges, CoCoRaHS*

CoCoRaHS is a unique, non-profit, community-based network of individual and family volunteers of all ages and backgrounds, who take daily measurements of rain, hail and snow in their backyards.

More information on CoCoRaHS and training materials can be found on its website at: http://www.cocorahs.org.

Be Safe

- Monitor local weather forecasts
- Get to higher ground before floods strike
- Do not cross flowing streams
- Never drive through water-covered roadways (road beds may be washed out under flood waters)

Check out the safety brochure *Floods the Awesome Power* at www.weather.gov/floodsafety/resources/FloodsTheAwesomePower_NSC.pdf.

For more information on the subject of the river forecasting process, visit our website at http://weather.gov/marfc or contact:

Service Coordination Hydrologist
NOAA, National Weather Service
Middle Atlantic River Forecast Center
328 Innovation Blvd., Suite 330
State College, PA 16803-6609

Photo: Potomac River, Great Falls, VA
Jim Palmer/ICPRB

Source: Use and Benefits of the National Weather Service River and Flood Forecasts, National Hydrologic Warning Council, Prepared by EASPE, Inc., May 2002

Source: Stream Gaging and Flood Forecasting A Partnership of the U.S. Geological Survey and the National Weather Service

Source: Flood photographs - Delaware County, NY Emergency Services http://www.dcdes.org