NOAA's National Weather Service

Hydrologic Information on the Web
A Manual for Users

Red River Flooding, March 19, 2010 Credit: NOAA/NOHRSC

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Introduction

NOAA's National Weather Service (NWS) provides a wide variety of hydrologic and hydro-meteorologic forecasts and information through the web. These web-based resources originate at NWS field, national center, and headquarters offices and are designed to meet the needs of a wide range of users from someone who needs the five-day forecast for a river near his home to the technically advanced water manager who needs probabilistic information to make long-term decisions on allocation of flood mitigation resources or water supply. The NWS will continue to expand and refine all types of web products to keep pace with the demands of all types of users.

Gateway to Hydrologic Web Resources

The gateway to hydrologic forecasts and information is entered at http://water.weather.gov or through the NWS home page (http://www.weather.gov) by clicking on the RIVERS, LAKES, RAINFALL link above the map.

National Map – River Observations and River Forecasts Tabs

The starting point for obtaining NWS hydrologic products on the web is a national map showing locations where observations are available for river/stream gaging station (Figure 1). Above the national map there are two rows of tabs. To access non-water related information, select tabs along the top row that are to the immediate left or right of the Water tab. The bottom row of tabs link to a specific map or menu and include: River Observations (default), River Forecasts, Experimental Long-Range River Flood Risk, Precipitation, River Download, and Other Information. The displays and other information available under these five tabs are discussed in this and other sections to follow.

When either the River Observations (default) or River Forecasts tabs above the national map are clicked, river/stream locations are displayed which are color coded according to the flood status of their most recent observation or the maximum forecast through the entire period as follows:

- **No Flooding (green)** – river/stream below level where flooding becomes a concern.
- **Near Flood Stage (yellow)** – flooding becomes a concern. River/stream is approaching or is forecast to approach the gage height – flood stage – where flooding is defined to begin. Flood stage is an established gage height for a given location at which a rise in water surface level begins to create a hazard to lives, property, or commerce.
- **Minor Flooding (orange)** - minimal or no property damage, but possibly some public threat.
- **Moderate Flooding (red)** - some inundation of structures and roads near stream. Some evacuations of people and/or transfer of property to higher elevations.
- **Major Flooding (violet)** - extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations.

The last three of these levels plus another not shown – record flooding – constitute the flood categories used by the NWS. While some degree of subjectivity is involved in determining flood

stage and the boundaries between minor, moderate, and major flooding, these categories have proven to be a valuable tool in describing the severity of flooding in all areas of the country. The upper left portion of Figure 1 is a sample map linked to the River Observations tab.

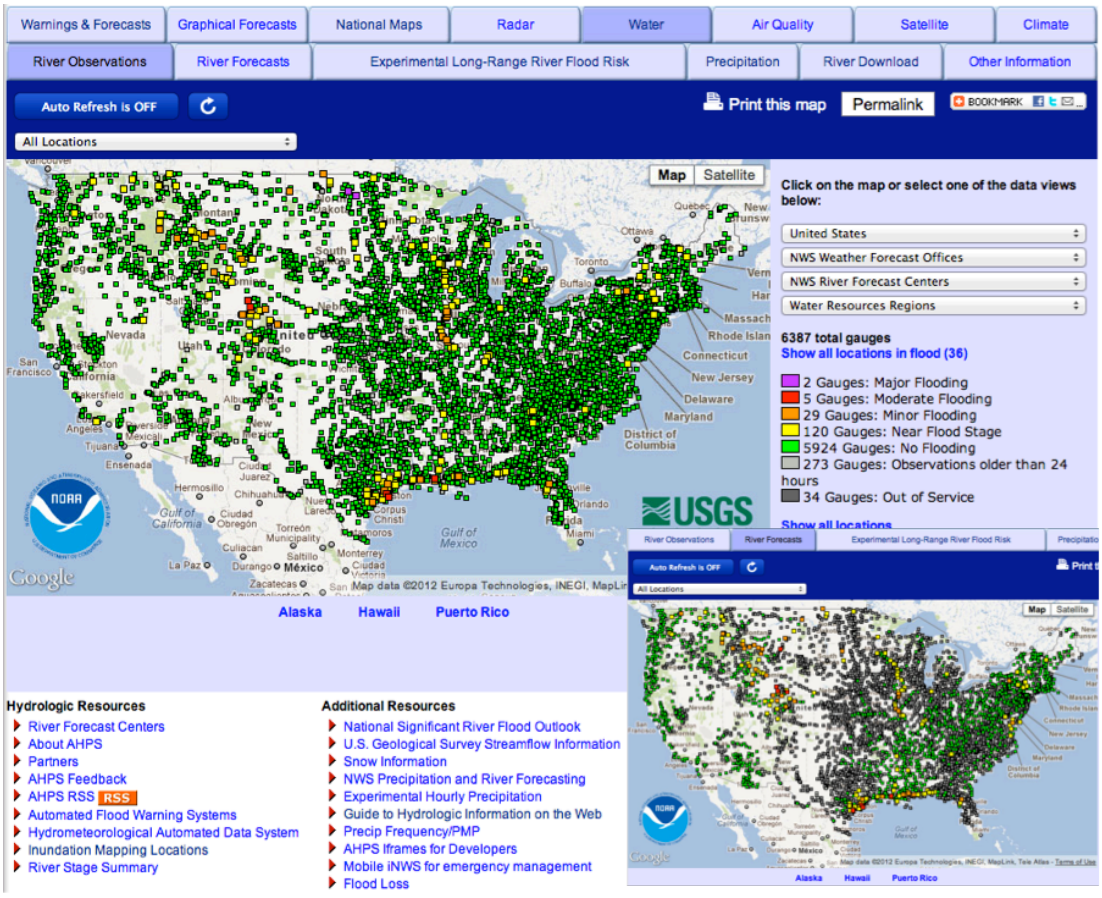

Figure 1. Portion of a sample web page for the NWS hydrologic web presence, showing default River Observations display and inset showing map linked to the River Forecasts tab.

The lower right portion of Figure 1 is a sample map linked to the River Forecasts tab. The River Forecasts map will show fewer locations than the River Observations map because river/stream forecasts (e.g., daily) are produced for fewer locations than where observations are available. NWS partners such as the U.S. Army Corps of Engineers and other users involved in river navigation, power generation, water management, emergency management, and similar water-related activities coordinate with the NWS on the river/stream locations, dams, reservoirs, and lakes which require routine forecasts. When high water or flooding occurs or threatens to occur, "non-routine" flood forecasts are issued for additional locations. Click here to view the current national river observations map and here to view the current national river forecasts map.

In the narrow dark blue area immediately below the tabs and above the national map, a white pull-down menu can be used to change the display of river/stream locations from all locations (default) to:

- **Hydrograph Only Locations** – hydrographs for individual river/stream locations provide a graphical overview of past and future conditions at a river/stream gage.

Selecting this option causes the map to show only the locations for which hydrographs are available.

- **Hydrograph/Probability Forecast Locations** – specialized products with information on the probability of future river levels/flows are also available for selected river/stream locations. Selecting this option causes the map to show only the locations for which these probability forecasts and hydrographs are available.

- **Inundation Mapping Locations** – at a small but increasing number of river/stream locations, specialized interactive displays depicting the amount of land inundated on each side of the river/stream at various stages are available. Selecting this option causes the map to show only locations for which these inundation maps are available.

Also available in the dark blue area are Auto Refresh, refresh, Print this map, Permalink, and Bookmark & Share buttons. Turn Auto Refresh on to have information on the map automatically update every 15 minutes. To immediately refresh information on the map, press the refresh button. A permalink is a uniform resource locator (URL) that links to a web page that does not automatically have a web address associated with it. For example, if you want to always return to a web page with a Google map that is zoomed into a particular view, you can create a permalink for it by clicking on the Permalink button.

Below the national map under the Hydrologic Resources section is a link to a map showing NWS River Forecast Center (RFC) areas of responsibility. The 13 RFCs produce river forecasts for their own area of responsibility.

Regional Maps: River Observations and River Forecast Tabs

Clicking on a point on the National River Observations or River Forecasts map brings up a regional map covering an individual NWS weather forecast office's (WFO) area of hydrologic responsibility (known as a hydrologic service area, or HSA) plus the surrounding area (Figure 2). Click here to view the current version of the HSA map shown in Figure 2. Most HSA maps cover all or portions of two or more states. For larger states, the map may cover only a portion of one state.

To the right of the National River Observations or River Forecasts maps, pull-down menus can be used to display river/stream locations across four types of regions. These regions include states, NWS weather forecast office HSAs, NWS River Forecast Center (RFC) areas of responsibility, and USGS water resource regions (Figure 3).

Users have more control over features displayed on regional maps than on national maps. Use the Google Maps zoom control slider bar to zoom in or out. Use the pan control to move the map to the left and right or up and down. Click on the Create zoom box tool to draw a square around an area that you want to zoom into. Clicking on the Reset View button takes you back to the original regional map.

River/stream gage locations on regional maps are color coded according to their current flood status using the same classification and color scheme as the National maps. Icons used for individual river locations provide additional information on the products available for a location.

If the icon is square, a hydrograph product is available for the location and if the icon is round, both hydrograph and probability products are available for the location.

Like the national map, regional maps have tabs across the top allowing users to specify information provided at that scale. The first two tabs – "River Observations" and "River Forecasts" –

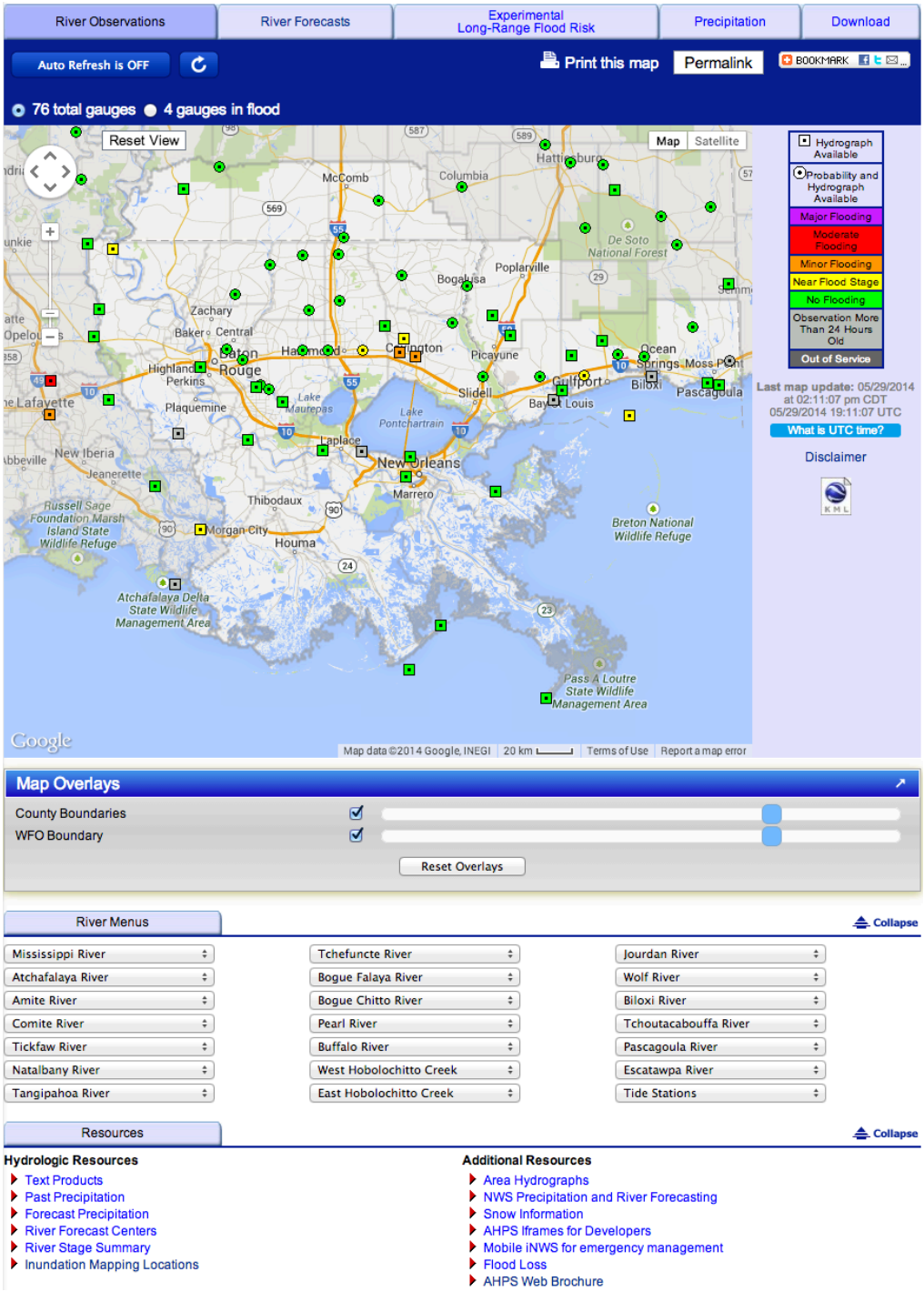

Figure 2. Portion of sample web page depicting river observation information at the WFO HSA level.

correspond to the first two tabs on the national map with similar titles. The default "River Observations" tab links

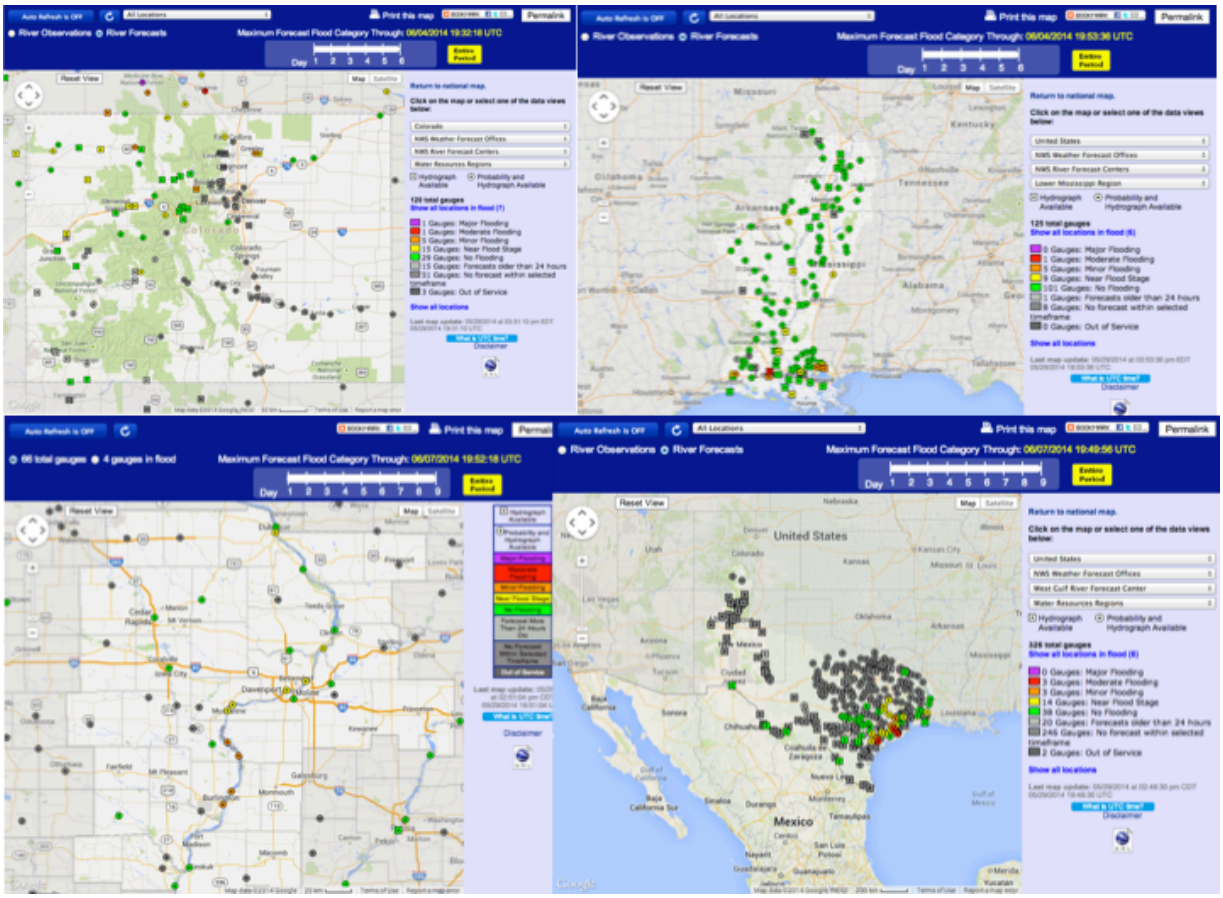

Figure 3. Portions of sample web pages depicting river forecast information at the state (upper left), WFO HSA (lower left), USGS water resource region (upper right), and River Forecast Center area of responsibility (lower right) levels.

to a regional map showing the flood status of the most current observation at river/stream gage locations. The "River Forecasts" tab links to a map that shows the maximum forecast flood category through the entire period at river/stream gage locations. Unlike the national map, a forecast timeline slider appears above the map and defaults to entire period. Because the period for which a forecast is prepared varies from RFC to RFC, the entire period generally ranges from 2 to 9 days. The forecast timeline slider has up to 9 tick marks and a yellow slider button. Each tick mark represents a day in the forecast period, ranging from day 1 on the far left to day 6 or 9 on the far right. When first bringing up a regional map, the forecast timeline slider button is at entire period, its default position. The locations on the regional map are color-coded according to their maximum forecast flood category through the entire period. To view the maximum forecast flood category through day 1, move the slider button all the way to the left to day 1. Above the forecast timeline slider, notice that the "Maximum Forecast Flood Category Through: day time" changes to "1-Day Maximum Forecast Flood Category Through: current day+1 time". Moving the forecast timeline slider button to the right to tick mark #9 displays locations that are color-colored according to their maximum forecast flood category through day

9. When moving the button, a loading spinner will appear. Once changes to the forecast timeframe are complete, the loading spinner will disappear. Because not every RFC produces river forecasts out to 9 days, it is normal to expect an increase in the number of river/stream gage locations being grayed out (shown as No Forecast Within Selected Timeframe) as one increases the forecast timeframe from day 1 to day 9.

River Location: Hydrograph Tab. Clicking on a color-coded river location on a regional "River Observations" or "River Forecasts" map brings up a small observed/forecast hydrograph for that location. Click on the tabs at the top of hydrograph to display Summary and Quick Links information for that river location. Click on the link below the hydrograph to bring up expanded information as shown in Figure 4. (Click here to view the latest hydrograph page for Killbuck Creek at Killbuck, OH).

Hydrograph plots are divided into left and right portions, separated by a vertical blue dashed line. The vertical line represents the "base time" for which the hydrograph was created, with past observations plotted to the left using blue dots and forecasts for the future (if available) plotted to the right using purple dots. The bottom scale for the hydrograph is labeled with dates and time. The river/stream stage[1], or gage height, in feet, is indicated along the left vertical axis of the observed/forecast hydrograph. The flow (discharge) corresponding to the stage is provided along the right vertical axis in cubic feet per second (cfs) or thousands of cubic feet per second (kcfs). Some readers may be more familiar with flows in gallons per minute, but hydrologists and engineers decided long ago that the numbers were too large when flows were expressed in those units. You may notice that each stage on the left side corresponds to a single flow on the right, and flow rate increases with stage. This is true except in the rare case of near-peak flood flows on rivers in very flat areas.

Information Below Hydrograph. A small yellow menu below the hydrograph provides access to:

- A printable .pdf version of the hydrograph,
- A definition of a hydrograph along with explanations of key terms used in the display,
- A tabulation of all the observed and, if available, forecast data shown in the hydrograph in UTC,
- A tabulation of all the observed and, if available, forecast data shown in the hydrograph in local time,
- A downloadable XML file containing all observed and, if available, forecast data shown in the hydrograph,

[1] Stage for a river or stream is provided in two ways – (1) height above a locally fixed level known as gage datum or gage zero and (2) absolute elevation above a fixed location in North America (at Father Point, Rimouski, Quebec, Canada) known as the North American Vertical Datum of 1988 (NAVD 88 – new standard) or an older datum known as National Geodetic Vertical Datum of 1929 (NGVD 29). 0.0 feet NAVD 88 or NGVD 29 is not the same as mean sea level (MSL), but they are fairly close (see http://tidesandcurrents.noaa.gov/datum_options.html for more precise definitions). In general, stages above locally fixed levels tend to be numerically smaller than elevations above NAVD 88 or NGVD 29, because absolute elevations are in the hundreds or thousands of feet in higher inland areas. Of course, this may not hold true for gages in low elevation areas near the coast.

- A description of how to automatically receive, via RSS, an XML-encoded version of the hydrograph you are viewing each time it is updated,
- The datum which stages are referenced to (NAVD 88 or NGVD 29), and
- A metadata (i.e., descriptive information on a location) table for the stream gage station.

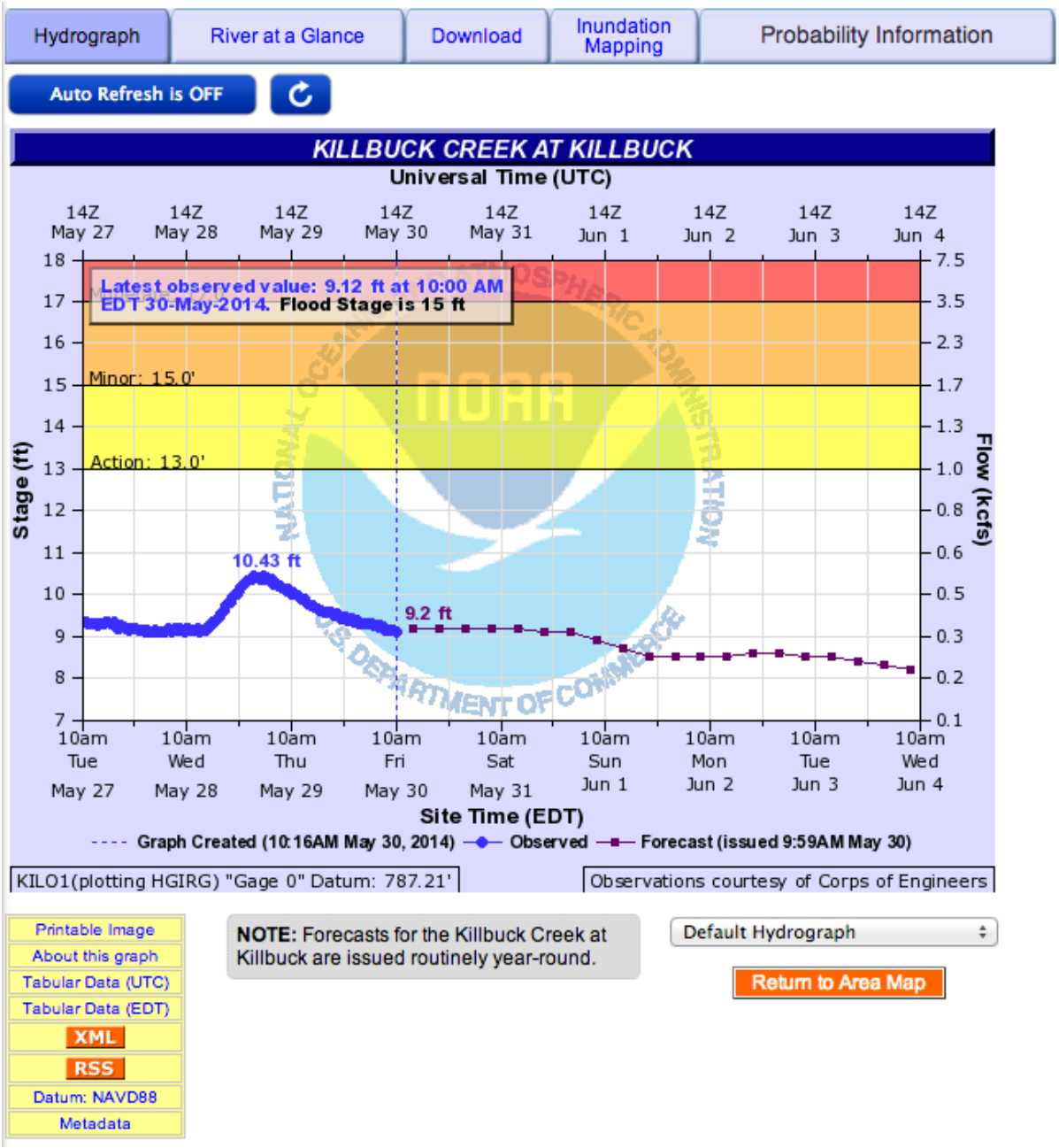

Figure 4. Sample hydrograph showing observed and forecast data.

Also below the hydrograph, a small pull-down menu to the right gives the user the option to display the hydrograph with a vertical scale that is close to the range of past, current, and future (if available) stages, or a vertical scale that is stretched out to include colored portions indicating the minor, moderate, and major flood categories as well as the action stage and record flood level. The former is the default display, but if a river/stream is already in flood or is forecast to be in flood, the hydrograph display will automatically include flood categories.

If the location currently being viewed has upstream and/or downstream gages, arrows labeled "Upstream Gauge" and "Downstream Gauge" can be found under the hydrograph and below the level of the yellow menu. This allows the user to review the hydrographs for river/stream locations in sequential order, which can be useful during a flood episode.

Still further below the hydrograph, a gage location map is provided with Google Map capabilities (Figure 5). To the left of this map, tables of historical crests and, if available, low water records are provided. This historical information is useful in comparing a current flood or low flow event to past events.

A list labeled "Flood Impacts" or "Flood Impacts & Photos" is provided below the gage location map and historical flood/low flow tables (Figure 5, lower half). This information describes impacts a river/stream will have at various upstream and downstream locations (e.g., roads, bridges, homes, commercial buildings, water treatment plants) at various stages. The lowest stage and associated impact is at the bottom of the list and the highest stage and most severe flood impact is listed the top. Photos of the river/stream gage locations may also be included.

Several tabbed sections are found below the flood impact list providing access to other kinds of information on the river/stream location (Figure 5). Each of these tabbed sections can be expanded or collapsed by the user. Information under these tabs includes:

- "About This Location," which provides the same information obtained when clicking on "Metadata" in the yellow menu box;
- "Resources," which provides links to several web locations where additional information supporting the decision making process during hydrologic events can be found;
- "Collaborative Agencies," which lists agencies at all levels of government with interests in hydrologic conditions at the location; and
- "NWS Information," which contains the address of the NWS weather forecast office (WFO) responsible for forecasts and warnings at the gaging station, a point of contact at the WFO, a disclaimer notice, and various NWS-related links.

River Location: River at a Glance Tab. Clicking on this tab allows the user to create a customized product for all or a subset of locations along a given river. Users select any combination of the following graphics and data to be included in this product: observed stage/flow and forecast hydrograph for the point; numerical observed stage/flow and forecast values; flood impact information; chance of exceeding stage, flow and/or volume levels during entire (long term) period graphic; weekly chance of exceeding stage, flow, or volume levels graphic; location map; historical crests; low flow, low water impacts, low water records, and downloadable RSS/XML files. Some of these items, such as the probabilistic products, are not available

for all forecast points. Therefore, the menu for selecting items to include in a customized product is not identical for all areas of the country. Click here to view the menu which appears after clicking on the "River at a Glance" tab for Killbuck Creek at Killbuck location.

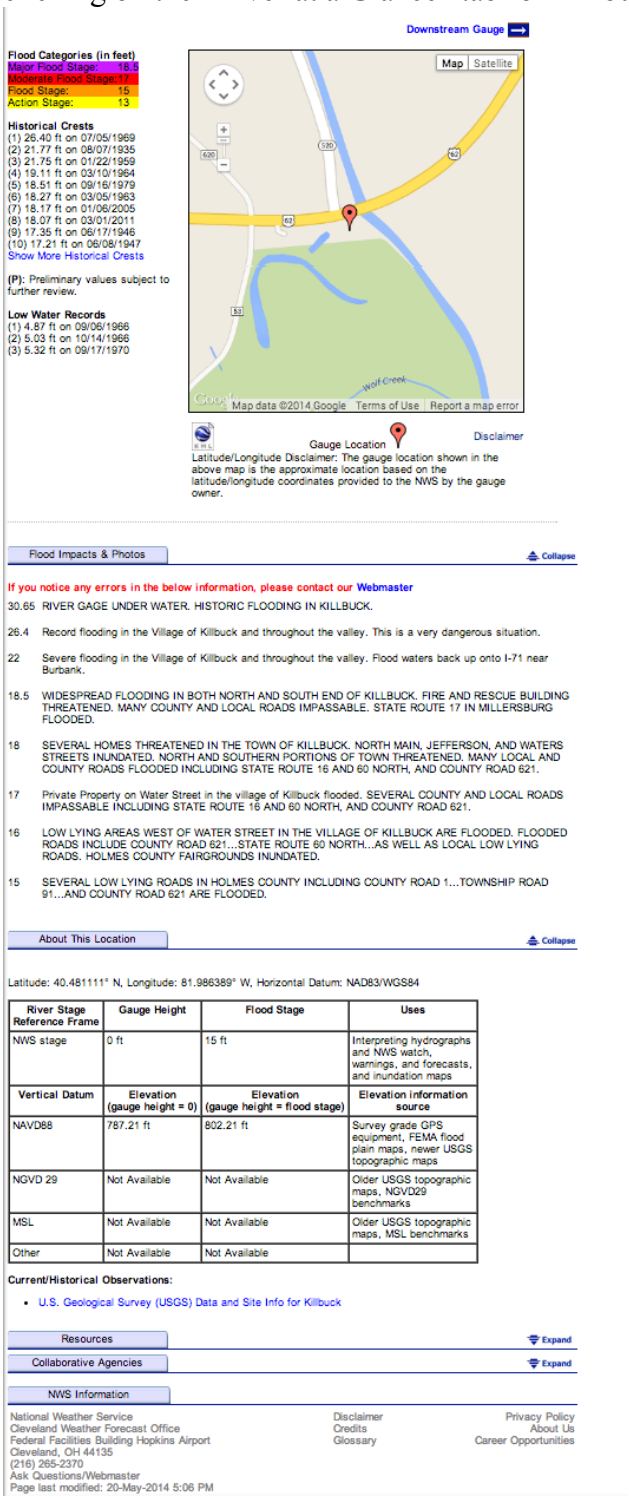

Figure 5. Sample gage location map, flood impact descriptions, and tabs for various types of information on a river/stream location.

River Location: Download Tab. Clicking on this tab brings up a menu providing for the download of several forms of information on the river/stream location, including an:

- Observed/forecast hydrograph image,
- Observed/forecast data and metadata on the forecast point in XML format,
- Criteria-based RSS feeds initiated by subscription, location map image,
- Weekly chance of exceeding levels image (discussed shortly),
- Chance of exceeding levels during entire (long term) period image (discussed shortly),
- Inundation map shapefiles,
- Inundation map KMZ files,
- Inundation map images, and
- Photos.

The number of options available varies by location. Click here to view the menu with the options appearing after clicking the "Download" tab for the Killbuck Creek at Killbuck.

River Location: Inundation Mapping Tab. The inundation mapping interface (Figure 6), if available for the location, is accessed through this tab. This feature is available for NWS forecast points where data sets known as flood inundation libraries have been developed through partnerships with federal, state, or local agencies. The inundation mapping interface provides information on the spatial extent and depth of flood waters in the vicinity of the forecast point. It provides the ability to view inundation levels at stage (to the nearest foot) in the minor, moderate, and major flood categories. Figure 6 shows inundation at a stage of 21 feet for Killbuck Creek at Killbuck. From this interface, the user can also view maps of observed or forecast inundation levels based on current NWS river forecasts. The user has the option to use either a Google street map background with or without terrain or a Google satellite imagery map with or without labels. Click here to view the current inundation map interface for Killbuck Creek at Killbuck.

Additional information on the inundation mapping interface is available at:

http://water.weather.gov/ahps2/inundation/inundation_mapping_user_guide.pdf

A user guide video on YouTube is available at:

http://www.youtube.com/watch?v=flyTdd7f2JI

Currently, a limited number of NWS forecast locations have a flood inundation mapping interface. A list of these locations can be found at:

http://water.weather.gov/ahps/inundation.php

As already mentioned, inundation map shapefiles, KMZ files, and images may be downloaded by clicking on the “Download” tab along the top of an inundation map.

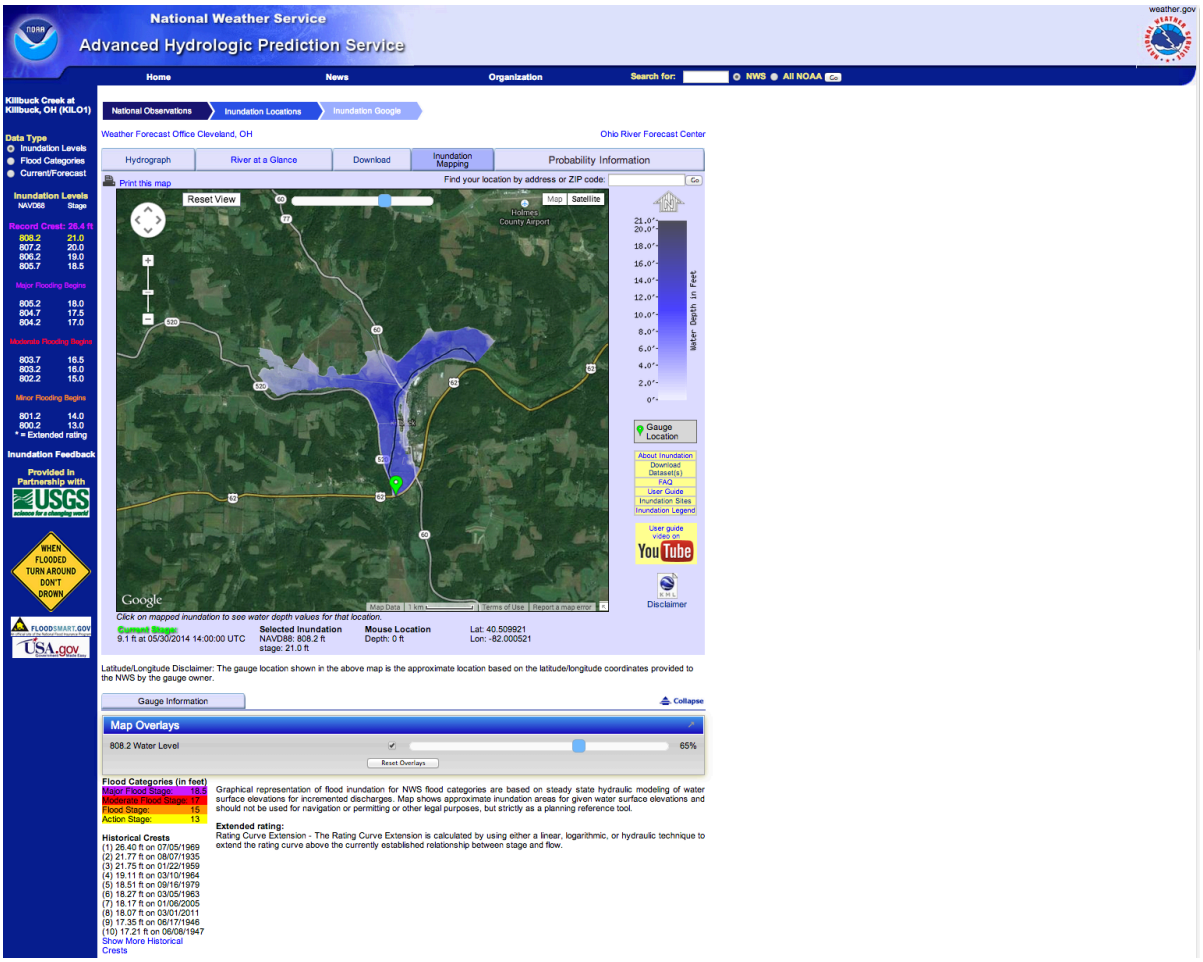

Figure 6. Sample Flood Inundation Mapping Interface.

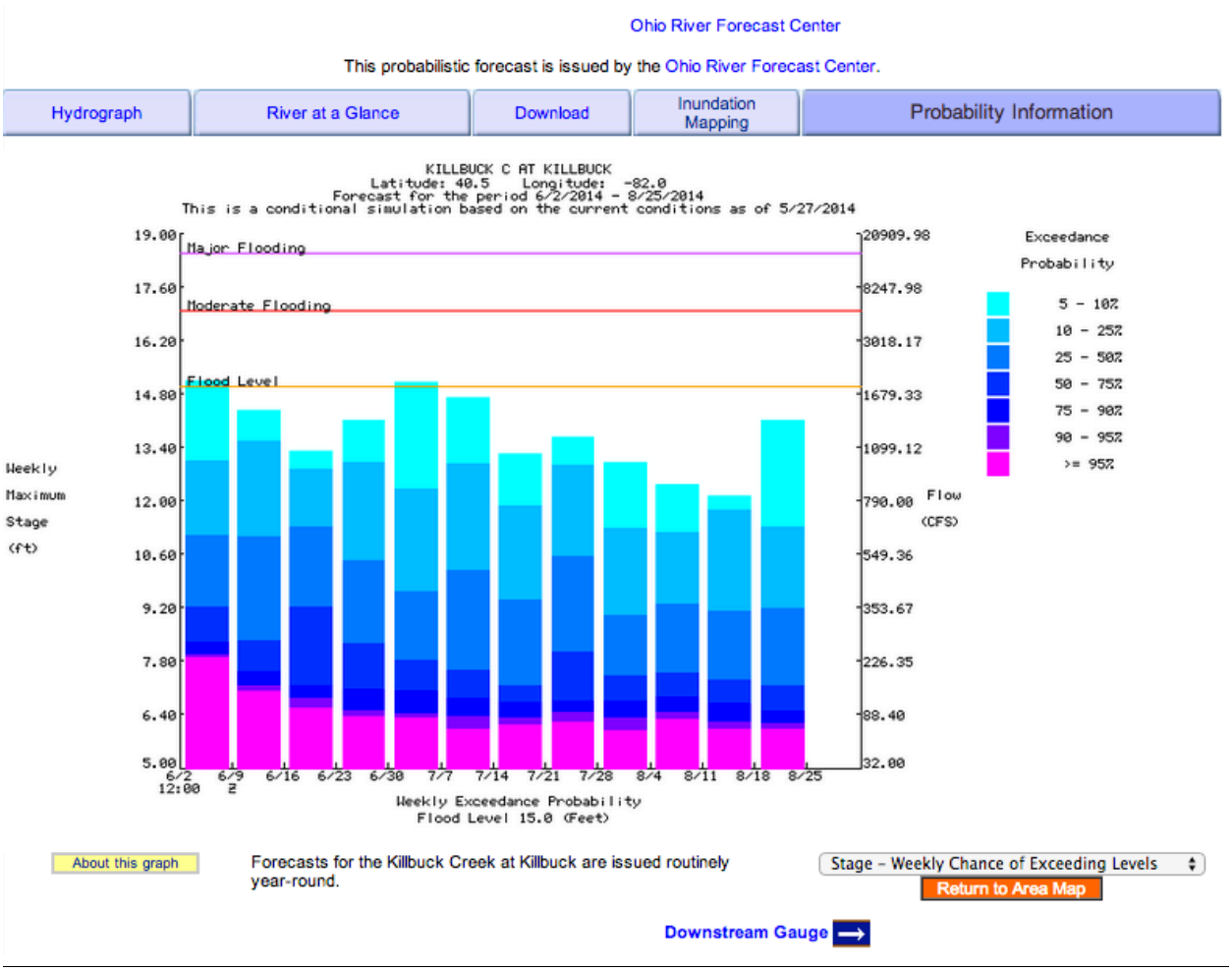

Figure 7. Sample Weekly Chance of Exceeding Levels product.

River Location: Probability Information (Weekly Chance of Exceeding Levels) Tab. Clicking on this tab brings up a graphical product showing the probability or chance of the maximum stage, flow or volume at a point on a river exceeding a particular value for consecutive 7-day periods in a 90-day interval. The vertical axis shows river stage or level measured in feet (ft) and the horizontal axis shows time. An individual multi-color vertical bar represents the exceedence probabilities for a 7-day period, each color representing a range of probability as defined in the key to the right of the graph. A sample display is provided in Figure 7. Click here to view the most recently generated Weekly Chance of Exceeding Levels product for Killbuck Creek at Killbuck.

River Location: Probability Information (Chance of Exceeding Levels During Entire Period) Tab. Clicking on this tab brings up a graphical product showing probability of the river stage, flow, or volume (the user selects one of these) going above various levels during the forecast period labeled above the graph (usually 30 or 90 days). A sample display is provided in Figure 8. This graphical product shows two sets of connected dots forming somewhat irregular traces which look somewhat like curving lines. These two traces can be described as follows:

- **Historical simulation (HS)**. A trace of small, blue dots indicating chances of a river going above the stages, flows, or volumes read along the vertical graph axis based on the total range of past levels in the long-term historical record (e.g., covering next 90 days).

- **Conditional simulation (CS)**. A trace of small, black triangles indicating chances of a river going above the stages, flows, or volumes read along the vertical axis. This trace is based on current weather and hydrologic observations plus the years from the historical record which are similar to the expected weather pattern as indicated in the long-term weather (climate) forecast (e.g., for next 90 days).

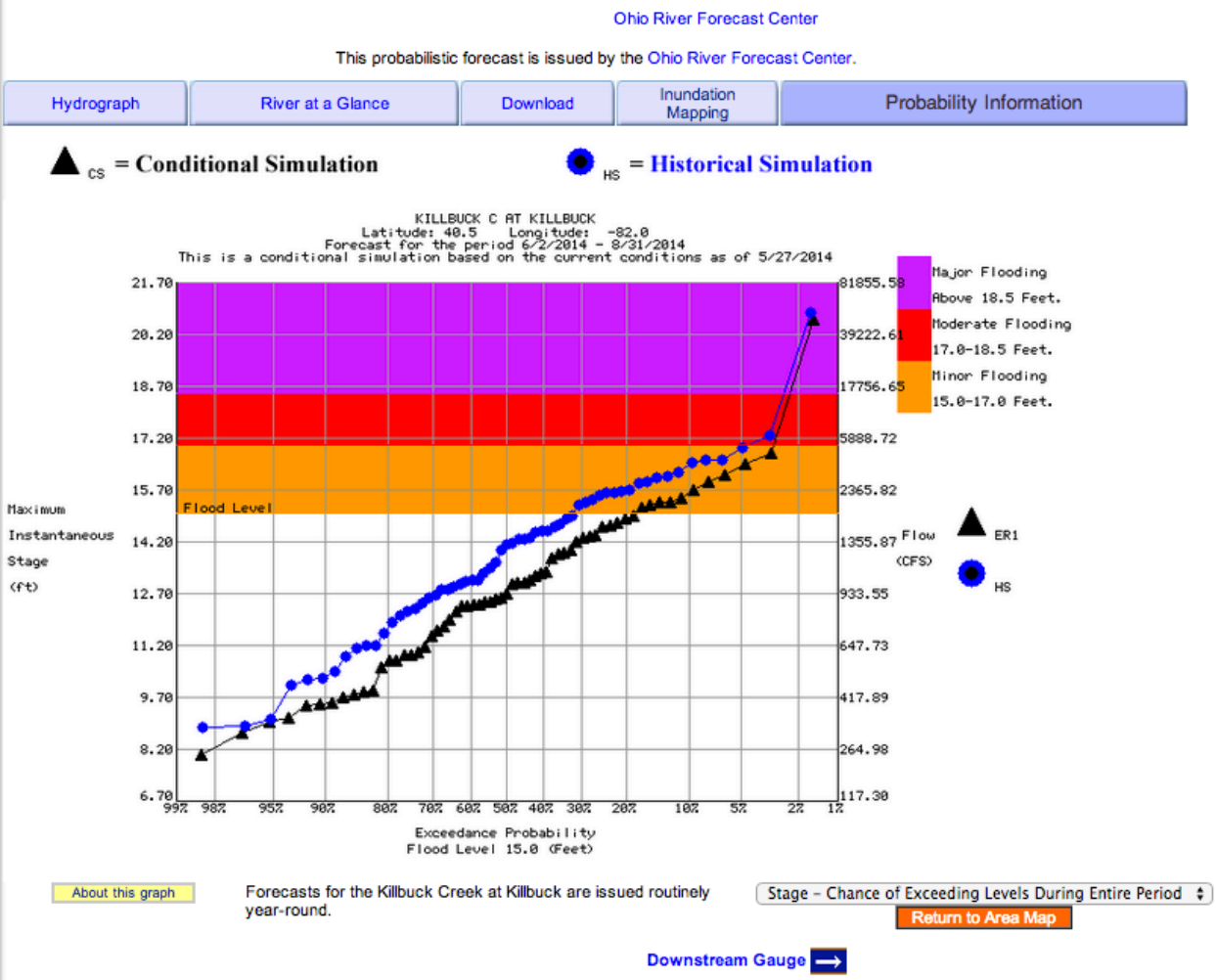

Figure 8. Sample Chance of Exceeding Levels During Entire Period product.

Chance of Exceeding Levels During Entire Period graphics may look a bit too technical and abstract at first, but they provide a significant amount of information on the probability of hydrologic conditions reaching various levels of impact during the next 1-3 months, including:

- If the black trace (conditional simulation) is above the blue trace (historical simulation), future river/stream flows are expected to be higher than normal. If the black trace is below the blue trace, (as in Figure 8), future flows are expected to be lower than normal.

- If the left portion of the black trace is level (for higher probabilities), the river was already at that level at the start of the long-term forecast period.

- Noting the probability on the horizontal axis where the traces first intersect the flood level (stage) and enters the orange (minor flooding) area of the graph gives an indication of the likelihood of future flooding. The higher the probability where the traces intersect flood stage, the more likely flooding is during the period covered by the graphic.

In Figure 8, the historical simulation crosses flood level at a probability of about 32% and the conditional simulation crosses flood level at a probability somewhere between 20 and 15%. This indicates the river was less likely to reach flood stage during the period than indicated by the historical record. Click here to view the most recently generated Chance of Exceeding Levels During Entire Period product for the same location (Killbuck Creek at Killbuck).

When are forecasts in these web products updated?

The hydrologic models used to generate near-term river/stream forecasts are generally executed in the morning on a daily cycle. When river/stream conditions are below flood levels, the forecasts as seen in the hydrographs are issued at fairly regular times in the morning. However, during flood/high water situations, much more data is coming in and forecasters may need additional time to analyze observations and model output, causing the forecasts to be issued somewhat later than usual. Updates to the forecasts are issued more frequently during flood/high water situations. Updated long-term products such as exceedence probability graphics may only be generated once or twice a month after new long-term weather (climate) forecasts are issued.

National Map – Experimental Long-Range River Flood Risk Tab

When the experimental long-range river flood risk tab is clicked on the National map page, a map showing locations that are color-coded according to the long-range (3-month) risk of minor, moderate, and major river flooding is displayed as follows:

- Less than X% chance of flooding (green)

- Greater than X% chance of minor flooding (orange)

- Greater than X% chance of moderate flooding (red)

- Greater than X% chance of major flooding (violet)

When first bringing up the experimental long-range river flood risk map, the percent (X) chance defaults to 50. Use the dropdown menu immediately above the map to select different percentages, including 5, 10, 25, 50, 75, 90, and 95. From the 1st to the 28th of every month, the 3-month period defaults to the current month-current month + 1-current month + 2. After the 28th of every month, the 3-month period defaults to the current month + 1-current month + 2-current month +3. Locations where long-range flood risk is not calculated are shown in gray.

Long-range (3-month) risk information is based on NWS Ensemble Streamflow Prediction (ESP) forecasts which are generated for thousands of river and stream forecast locations across the nation. With this capability, stakeholders, such as local emergency managers, can quickly view flood risk at the levels which are known to affect their specific area of concern.

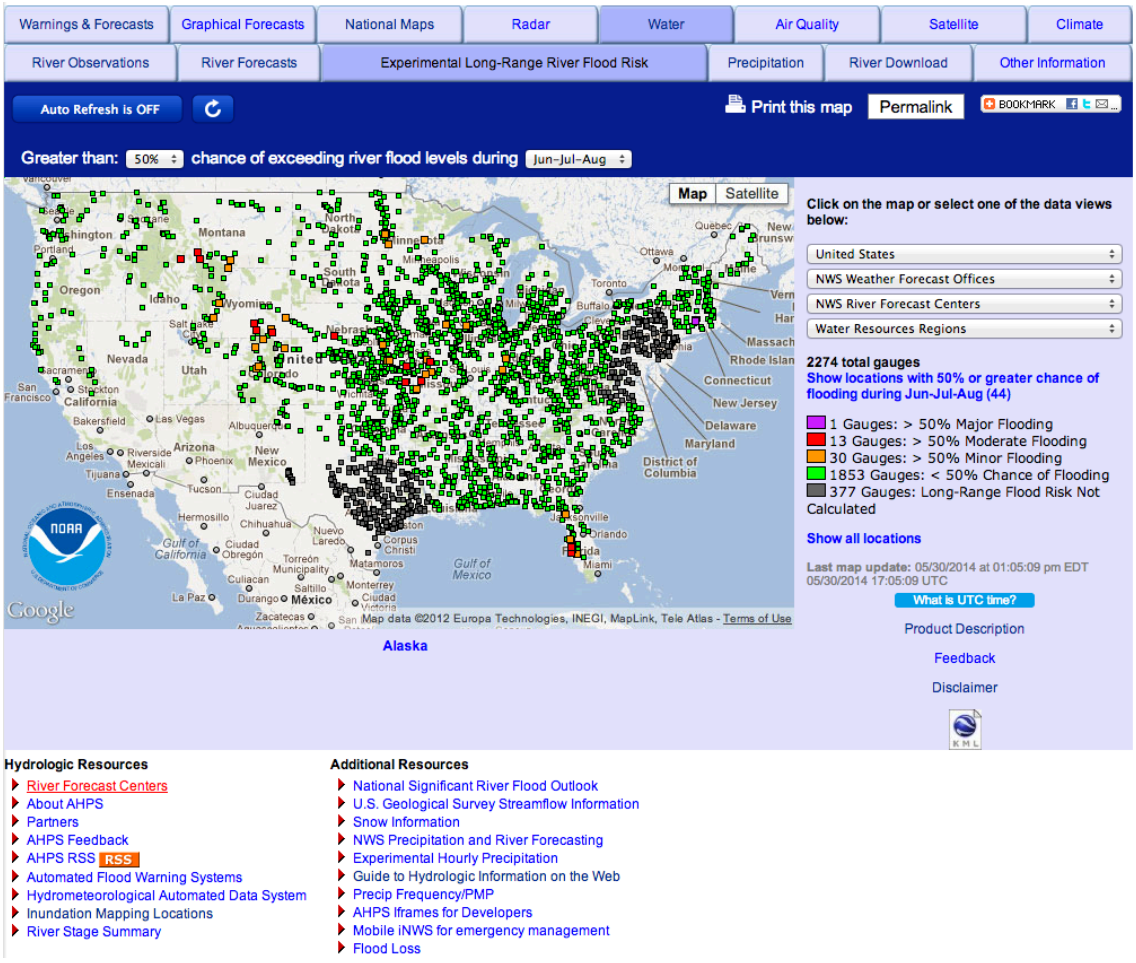

Figure 9. Portion of a sample web page for the NWS hydrologic web presence showing default Experimental Long-Range River Flood Risk display.

National Map - Precipitation Tab

When the precipitation tab is clicked on the National map page, a map showing observed 24-hour precipitation in the conterminous U.S. (CONUS) and Puerto Rico is displayed, along with a new third row of tabs immediately above the map and a large menu area with multiple selection options below (Figure 9). This national precipitation map is the default display for the new third row of tabs and initially depicts observed precipitation for the most recent 24-hour period ending at 1200 Coordinated Universal Time (UTC). 1200 UTC is used because it marks the end of the "hydrologic day" – a standard used in river modeling – and it is also when many daily weather observations are taken in the morning. This map integrates 24-hour totals of multi-sensor precipitation estimates from the 12 NWS river forecast centers (RFC) serving the lower

48 states. Multi-sensor precipitation estimates are produced by integrating radar-based precipitation estimates, satellite-based precipitation estimates, and ground-based precipitation gage data. The default map is initially set to display at the CONUS scale, with an inset to the bottom right for Puerto Rico.

Several menus below the precipitation map giver the user control over the information displayed. The menu along the left side allows users to select to view current precipitation for the most recent 24-hour period (default), as well as totals for the last 7, 14, 30, 60, 90, 180 days, month to date, year to date, and water year (starts Oct. 1) to date. The user can also display archived data by year/month, calendar year total, and water year total, with the option to display normal, departure from normal, and percent of normal for the time period covered by the archived data being viewed. Normals in the western U.S. were calculated using the PRISM analysis, a technique developed by Oregon State University to account for variability of precipitation in mountainous areas. Menus further right provide control over the geographical area displayed, including the continental U.S. + Puerto Rico, individual states, regions of the country, NWS river forecast center areas, and NWS weather forecast office areas. A small menu at the far right controls whether data displayed in English (as used in U.S.A.) or metric units.

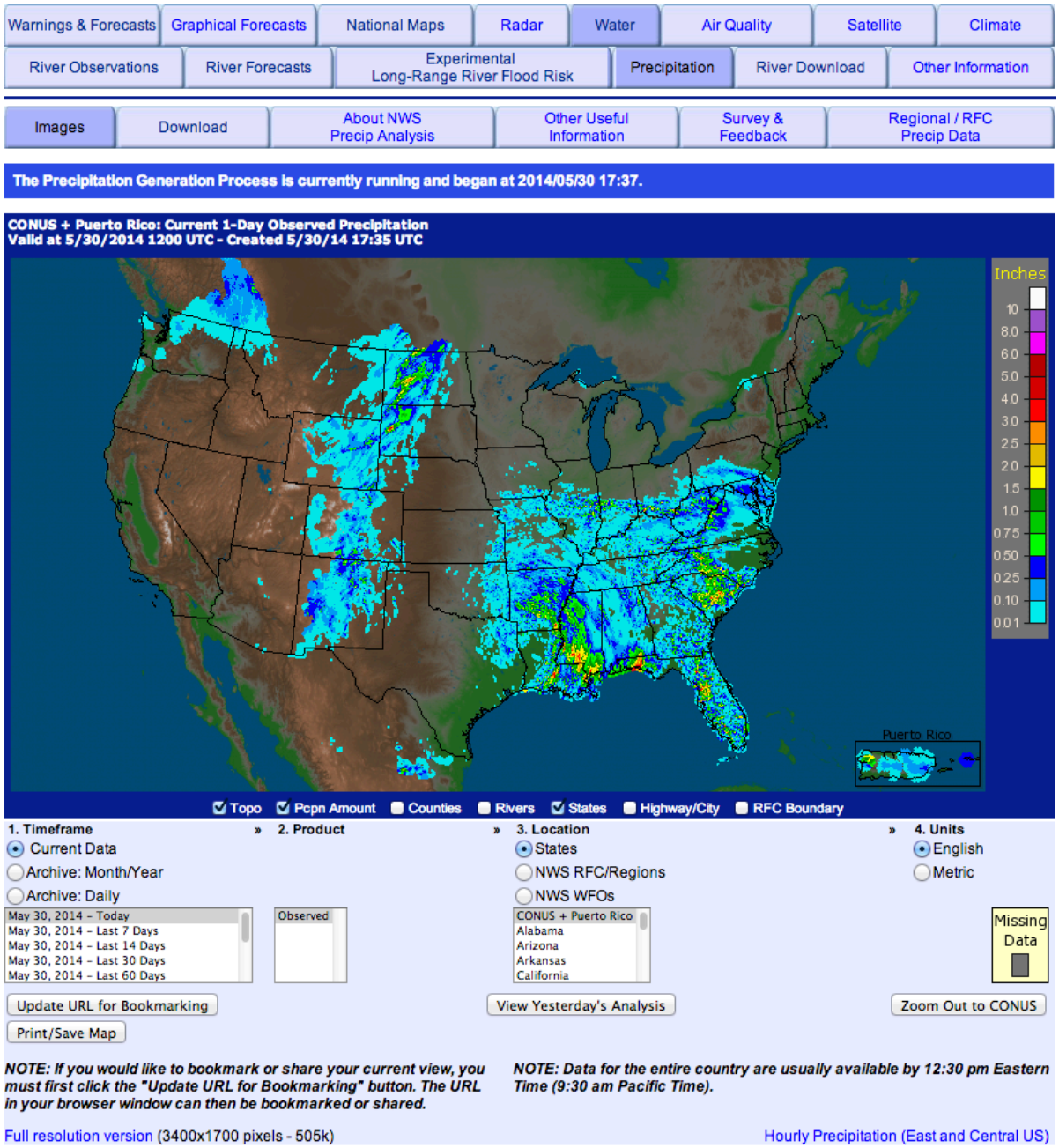

Figure 10. Sample national scale observed (24-hour) precipitation display.

The other tabs in the third row immediately above the national precipitation map allow users to interact with multi-sensor precipitation data in several ways:

- The "**Download**" tab allows current or archived precipitation data to be downloaded as gridded digital data in either shapefile or netCDF format.
- The "**About NWS Precip Analysis**" tab brings up an in-depth discussion on how the data is acquired and brought into the format seen in the display.

- The "**Other Useful Information**" tab brings up a condensed list of links to other related climate, water, and weather information.

- The "**Survey & Feedback**" tab provides instructions and links for various ways feedback can be provided to the NWS on the usefulness of information available through the precipitation web page.

- The "**Regional/RFC Precip Data**" tab provides access to the precipitation data sets from most RFCs that were contributed to this national precipitation web page. Links to experimental precipitation products being tested by the NWS may also be provided here.

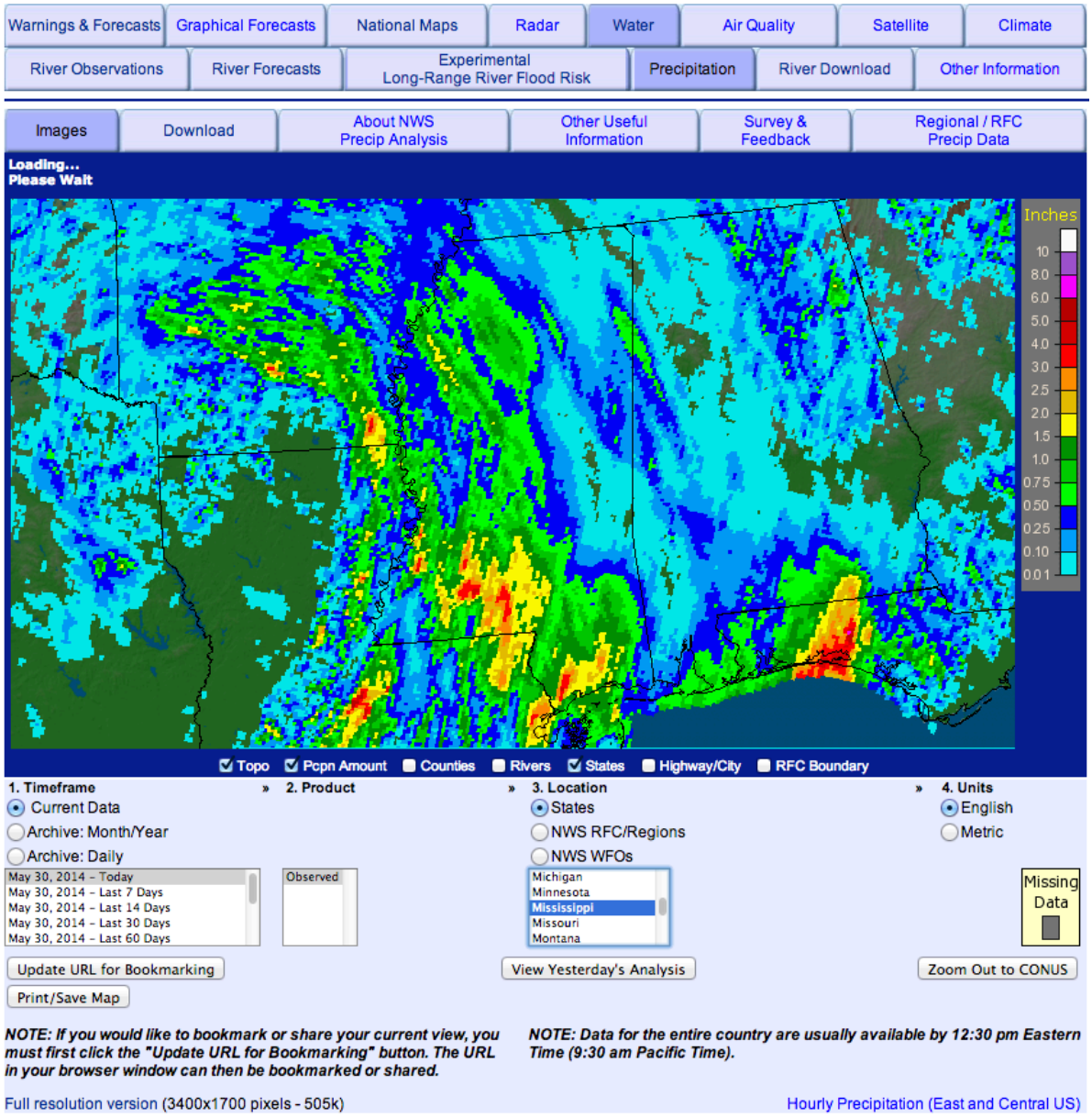

Figure 11. Sample state scale precipitation display.

State Precipitation Map

If any state in the national map is clicked on, an observed precipitation map for the state and its surrounding area is displayed (

Figure 11). The color scheme and user interface is the same as that provided for the national level. For any data being viewed at the national level that can be specified using the menus under the map (e.g., last 7 days, departure from normal), clicking on any state will cause the corresponding map at the state level to be displayed which uses the same color scheme. Observed precipitation for an individual WFO area can also be displayed.

When is the precipitation map updated?

The data sets used to produce national, state, and weather forecast office scale precipitation maps are updated on a daily basis. An update for the entire U.S. is usually ready by about 1730 UTC[2]. A message will appear immediately above the map to notify users if the precipitation generation process is running and when the process began.

National Map – River Download, Other Information Tabs

The River Download tab provides access to observed and forecast data for all locations in the CONUS and Puerto Rico in shapefile and KMZ formats as well as RSS/XML. Shapefile and netCDF formatted precipitation information is also available.

The Other Information tab provides links to a variety of other NWS climate, water, and weather information, including water supply information, climatological information, snow information, drought information, and seasonal information.

[2] 1730 UTC is 12:30 p.m. EST (1:30 p.m. EDT), 11:30 a.m. CST (12:30 p.m. CDT), 10:30 a.m. MST (11:30 a.m. MDT), 9:30 a.m. PST (10:30 a.m. PDT), and 8:30 a.m. AKST (9:30 a.m. AKDT)

National Significant River Flood Outlook

The National Significant River Flood Outlook identifies areas where potential exists for significant river flooding over the coming 5-day period. It is not intended to depict all areas of minor flooding or small-scale events such as localized flooding or flash flooding. This graphical product is accessed at:

http://www.hpc.ncep.noaa.gov/nationalfloodoutlook/index.html

As it is used in this product, "significant flooding" corresponds to the moderate and major flood categories, which can be described as follows (see NWS Manual 10-950 - *Definitions and General Terminology*):

> **Moderate Flooding** – involves some inundation of structures and roads near the river/ stream. Some evacuations of people and/or transfer of property to higher elevations are necessary.
>
> **Major Flooding** – involves extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations are necessary.

The National Significant River Flood Outlook covers the lower 48 states and is created by the Weather Prediction Center in the National Centers for Environmental Prediction by joining together individual graphical outlooks from the 12 NWS river forecast centers serving the lower 48 states. A separate significant river flood outlook for Alaska is provided by the Alaska-Pacific River Forecast Center (click here to view current outlook). Outlooks for both the lower 48 states and Alaska are posted on the Web once a day by approximately 2100 UTC (4 p.m. EST).

The National Significant River Flood Outlook provides links to the flood outlooks produced by individual RFCs. Each RFC's significant river flood outlook links back to the National product. Using the color scheme and patterns shown in Figure 12, flood potential is characterized in the National Significant River Flood Outlook according to the following criteria:

a. Possible: Hydrometeorological conditions indicate that significant flooding could occur. Such flooding is neither certain nor imminent.

b. Likely: Hydrometeorological conditions indicate that significant flooding can be expected during the outlook period.

c. Occurring/Imminent: Significant flooding is already occurring or is imminent during the outlook period.

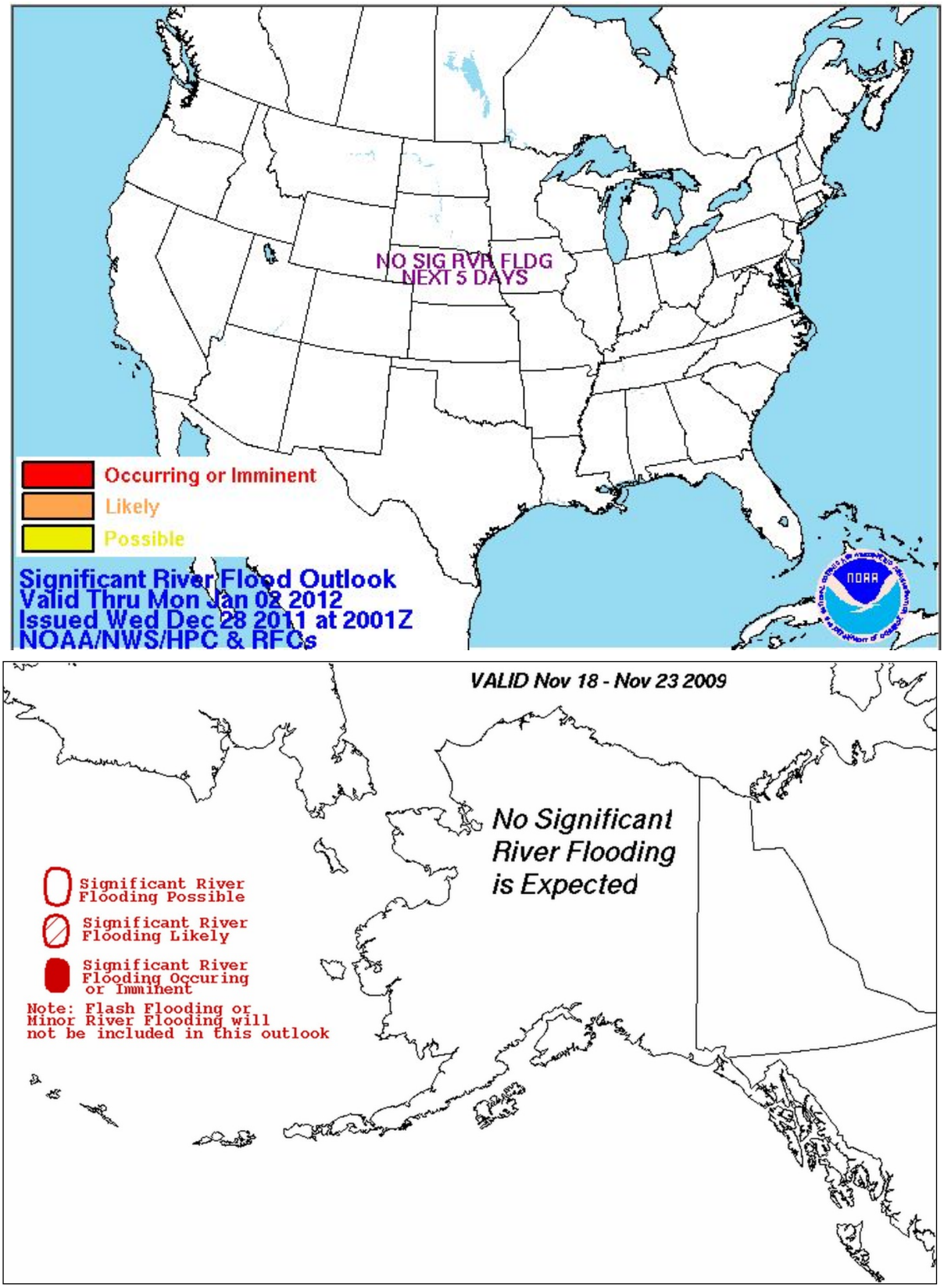

Figure 12. Sample National Significant River Flood Potential Outlook for CONUS and Alaska.

Precipitation Frequency Data Server

Civil engineers and others involved in the design of structures that will affect or be affected by runoff and streamflow caused by precipitation are concerned with extreme precipitation events. For some structures, extreme precipitation events as short as five minutes must be considered while others must take longer duration (e.g., multi-day) events into account. Statistical techniques have been used to calculate frequency estimates of precipitation intensities for a wide range of frequencies and durations. Such estimates are used in the design of a variety of structures from urban storm water drainage systems to dams and spillways.

In 1953, the National Weather Service began publishing precipitation frequency estimates – commonly known as intensity-frequency-duration values – in hard copy Weather Bureau Technical Papers and Memoranda. After NOAA was formed in 1970, they were provided in NOAA atlases. The estimates in these documents became de-facto national standards for a wide variety of design and planning activities at the federal, state, and local levels as well as in the private sector.

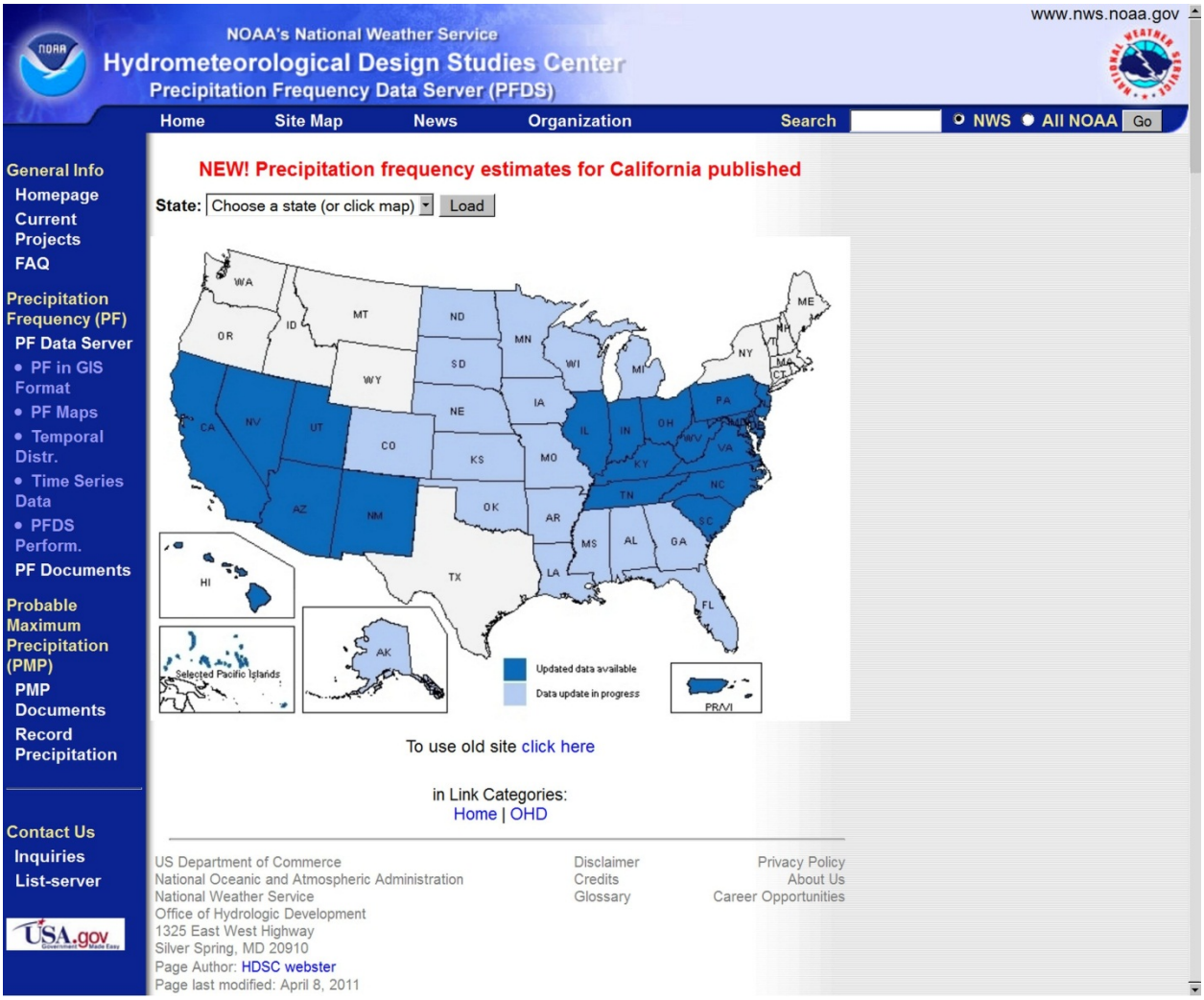

Figure 13. Precipitation Frequency Data Server home page.

The Precipitation Frequency Data Server home page (http://hdsc.nws.noaa.gov/hdsc/pfds/), as shown in Figure 13, is now the mechanism by which precipitation frequency estimates are provided by the National Weather Service. In general, the server provides these estimates in two formats:

1) New Format. For areas where recent statistical analyses have been performed to provide updated estimates for new volumes of NOAA Atlas 14, an interactive web capability is available which allows users to access digital output for any location interactively selected on a map (see example in Figure 14).

2) Old Format. For areas of the U.S. where updated estimates are yet to be derived, data are provided online in the form of scanned versions of the old Weather Bureau Technical Papers, Memoranda, and NOAA atlases (see example in Figure 16). Once the entire document appropriate to the location selected is retrieved by the server, the user must locate the map corresponding to the required frequency (e.g., 100-year) and rainfall duration (e.g., 24 hours), visually locate the point of interest on the map, and interpolate the precipitation depth from the isohyets (lines of constant precipitation depth).

On the Precipitation Frequency Data Server home page's national map, areas where updates have been completed for a new volume of NOAA Atlas 14 are shown in dark blue, areas where updated statistical analyses have not yet been performed are shown in white, and areas where updates are currently in progress are shown in light blue. Precipitation frequency estimates in the new digital format are provided for any user-selected location in the dark blue areas of the map, while estimates for the white and light blue areas are provided in the old format.

If a user clicks on one of the dark blue states on the national map, an interactive (Google) map of that state and its surrounding area is displayed. Initially, a red selection cursor will appear at the center of the state map, along with a table of precipitation frequency estimates for that central location displayed immediately below. A user can then move the cursor to any desired location and zoom into progressively more localized areas with a standard slide mechanism. Across the top of the map, pull-down menus give the user control of whether precipitation depth or precipitation intensity frequency estimates calculated based on statistical analysis of partial duration or annual maximum series are displayed in English or metric units. The map and accompanying menus give the user four ways to obtain digital precipitation frequency estimates for a location:

- Manually enter a latitude and longitude (decimal degrees) of a desired location
- Select one of the historical observation locations from a pull-down menu. These represent locations where a historical record of observations was available for use in the analysis conducted to derive the precipitation frequency estimates.
- Select one of the green historical observation location icons on the map (the "show stations on map" box must be checked and the map must be zoomed in at least one increment from initial display).
- Drag the red cursor to select any location on the map.

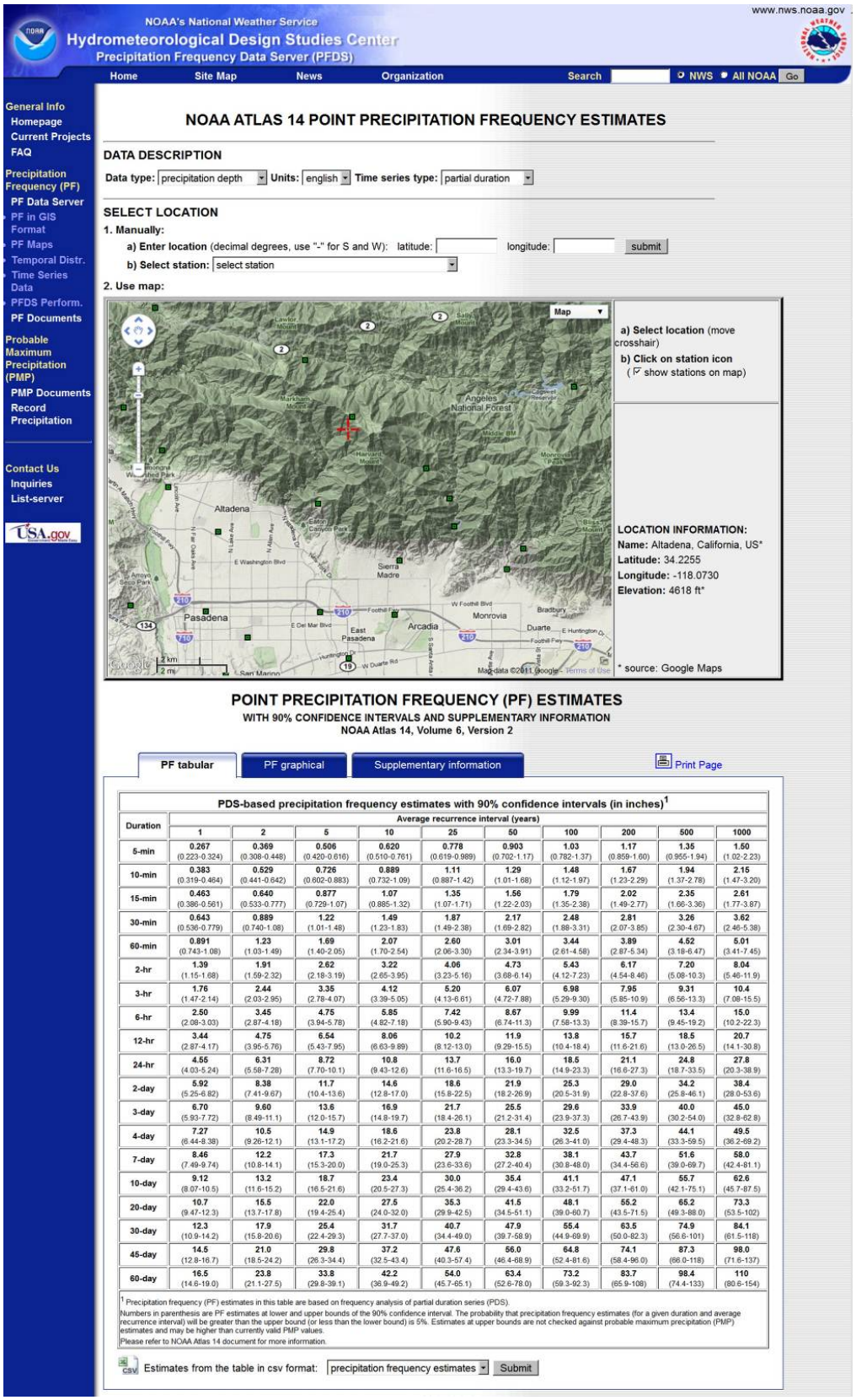

Figure 14. New format – digital precipitation frequency estimates for a location produced by the Precipitation Frequency Data Server from a new volume of NOAA Atlas 14.

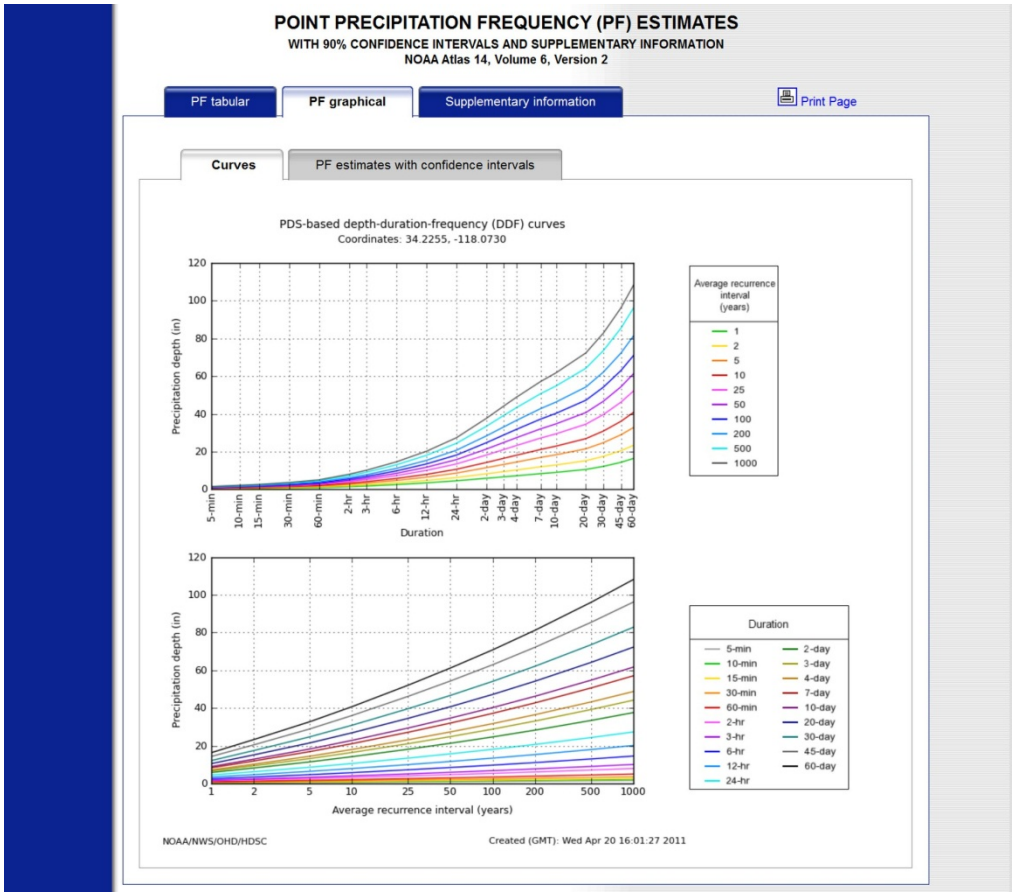

Figure 15. New format – precipitation frequency estimates displayed in graphic form for the same location used in **Figure 13.** This is displayed by clicking on the "PF graphical" tab.

After one of these four ways has been used to select a specific location, a table of precipitation frequency (PF) estimates with corresponding upper and lower bounds of 90% confidence interval is displayed for the location as shown in the bottom half of Figure 14. As can be seen in this figure, this table is actually the default display associated with the first of three tabs (PF tabular). The tabular data can also be downloaded as comma-separated values (.csv) by selecting the type of data (mean estimates, upper bound, lower bound, or all) via a button beneath the table. The second tab, PF graphical, provides access to graphical representations of the same information provided under the first tab (Figure 15). The third tab, Supplementary information, provides access to the following:

- Document. The on-line volume of NOAA Atlas 14 describing the in-depth study that was conducted to derive updated precipitation frequency estimates for the project area encompassing the selected location.

- PF in GIS format. Spatially interpolated precipitation frequency estimates for a user-selected frequency and duration (with upper and lower bounds of the 90% confidence interval) in GIS compatible formats.

- PF cartographic maps. State maps with colorized isopluvials (lines of constant depth) of precipitation frequency estimates for selected frequencies and durations.

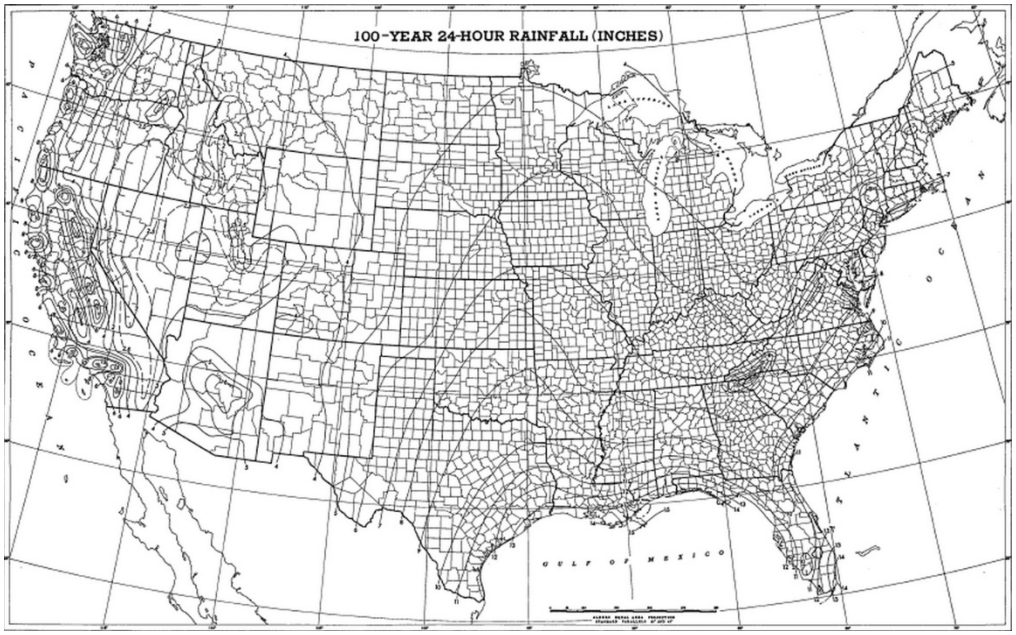

Figure 16. Old format – national map with lines of constant depth for 100-year, 24 hour precipitation, scanned from Technical Paper No. 40 and provided via the Precipitation Frequency Data Server.

- Temporal distributions of heavy precipitation. Files (.csv), viewable as spreadsheets in MS Excel, containing cumulative percentages of precipitation totals at various time steps which can be used to calculate the temporal distribution of precipitation frequency estimates for 6-, 12-, 24-, and 96-hour durations.

- Seasonality analysis. Graphs showing the monthly distribution of precipitation totals (percent of total recorded events) for all stations in each climate sub-region that exceeded the precipitation frequency estimates for 50, 20, 10, 4, 2, and 1 percent annual exceedence probabilities for user-selected durations of 60 minutes, 24 hours, 2 days, or 10 days.

- Rainfall frequency estimates. Rainfall (liquid precipitation only) frequency estimates for 60-minute, 2-hour, 3-hour, 6-hour, 12-hour, and 24-hour durations. These tables provide estimates for rainfall only, as opposed to the main precipitation estimate tables (as shown earlier in Figure 14), which apply to all forms of precipitation (e.g., including snow). Differences in these types of estimates will only be relevant for higher elevations.

- Time series data. Annual maximum series precipitation data are available if an observing station has been selected on the interactive map or from the pull-down list. Partial duration series data are currently only available for areas covered by NOAA Atlas 14, Volumes 1-3.

- Climate data source. Links to general information on data sites near the currently selected location which use the search engine of NOAA's National Climatic Data Center (NCDC). User can select all stations within ± 30 minutes (1/2 degree) or ± 1 degree. Not all stations obtained through this search will have necessarily been used in the study to calculate precipitation frequency estimates.

- Watershed information. A link that can be used to obtain information on the watershed containing the location of interest from the U.S. Environmental Protection Agency (EPA) web site.

National Snow Analysis

Snow and snow information is of critical importance to the Nation's economy. Information on snowpack conditions is essential to support river, flood and water-supply forecasting, agriculture and forest management, recreation and tourism, and the commerce, industry and transportation sectors of the Nation's economy. The National Snow Analysis (NSA) produced by the National Operational Hydrologic Remote Sensing Center (NOHRSC) in Chanhassen, MN, offers users a variety of web-based snow information available in near real-time (http://www.nohrsc.noaa.gov).

The NOHRSC uses daily ground-based, aircraft, and satellite snow observations from all electronically-available sources coupled with numerical weather prediction models to drive a sophisticated snow model known as SNODAS (SNOw Data Assimilation System)[3]. SNODAS products are available in a variety of interactive map, text discussion, alphanumeric, time-series, and gridded formats through the NSA.

The home page for the National Snow Analysis is: http://www.nohrsc.noaa.gov/nsa/ (Figure 17). From the NSA page, users can access many forms of snowpack-related information including some of the observational data sets used in the snowpack modeling process. In the dark blue margin on the left side of the NSA page, a list of main categories and clickable sub-categories controls the current display. The following is a "tour" of NOHRSC products and services that are available via the clickable categories on the left margin of the NSA web page.

Snow Information Heading – National Analysis

The NSA home page is shown in Figure 17. This home page shows a large U.S. map above nine smaller maps depicting the following modeled snow parameters: snow water equivalent, snow depth, average snowpack temperature, snow water equivalent change, snow precipitation, snow melt, blowing snow sublimation, surface sublimation, and non-snow precipitation. The larger U.S. map is divided into 18 geographic areas. Snowpack conditions for each of these 18 areas (e.g., Northern Rocky Mountains) can usually be summarized on a regional basis. When a user clicks on one of these geographic areas in the large map, the small maps will display the region of interest. The user can access past information by selecting a year, month, day and region using the pull-down menu between the large and small maps. For any one of the nine maps, the user can animate the variable displayed. The "season" animation loops through daily data for the snow season, beginning on October 1 and proceeding to the present. The "two weeks" and "one day" animations loop through hourly data. The animations are helpful for visualizing broad spatial changes in snowpack characteristics over time.

The NSA page also includes a table to the right of the large U.S. map summarizing the most recent snow model analysis including percent of the U.S. (or selected geographic region) covered by snow and modeled snow depth and snow water equivalent statistics. A separate table below the maps highlights the top ten snowfall observations for the country or for a specified snow region.

[3] SNODAS is an energy-and-mass-balance, spatially-uncoupled, vertically-distributed, multi-layer snow model run operationally at 1-km² spatial resolution and hourly temporal resolution for the nation. Ground-based and remotely-sensed snow observations are assimilated into the simulated state variables of the snow model.

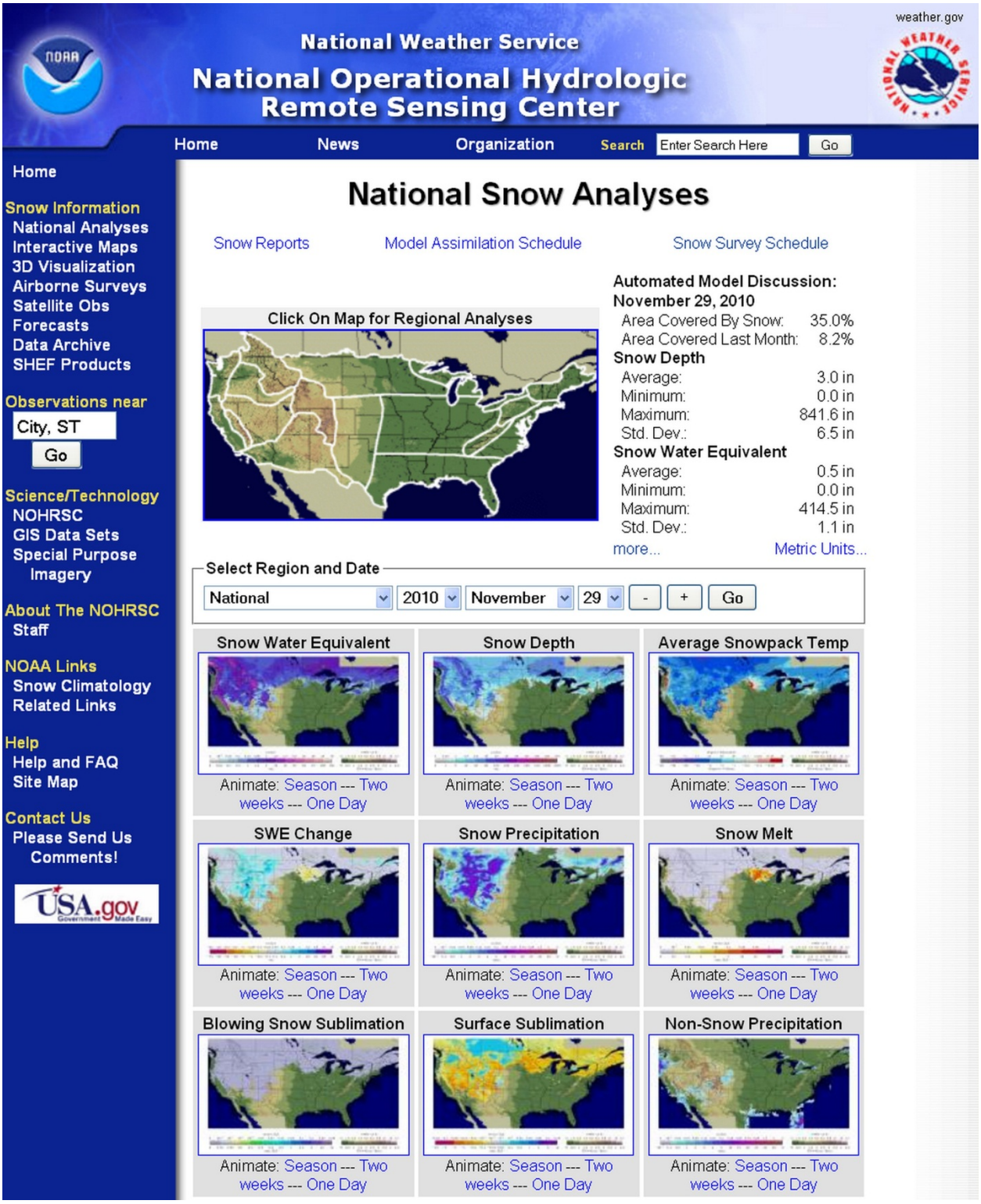

Figure 17. Home page for the National Snow Analysis.

Below the maps are links to station snowfall, snow water equivalent and snow depth reports. Clicking on any one of those links will bring the user to a table with observations for whichever geographic region is selected in the maps above.

Near the bottom of the NSA page is a section describing the most recent snow data assimilation and a section describing upcoming airborne snow surveys. Both the assimilation description and survey schedule will update depending on which region is selected in the maps.

Snow Information Heading – Interactive Maps and Time Series

Interactive Maps

For users who need more spatial and temporal flexibility than what is provided in the default NSA display, the Interactive Maps link provides access to a powerful Web-based interactive tool (Figure 18) for accessing and viewing snow information. It is not practical to completely describe every capability of this interactive display, but some of its highlights include the following:

- Any of the following physical elements (data types) can be selected for display on the map: hourly and daily elements related to snowpack condition (e.g., hourly snow water equivalent, 24-hour change in snowpack temperature), daily and hourly elements driving snowpack conditions (e.g., surface air temperature), archived satellite snowpack observations, climatic data elements (e.g., freezing degree days), observational elements (e.g., total precipitation), and static NOHRSC model datasets, such as elevation and forest cover density.

- One or more overlays can be selected for display on the map, including hydrologic, political, civic, transportation and other features.

- A box labeled "Navigation tools" at the top of the page can be used to re-center the map and zoom in on a point of interest. These tools can be used to change the extent of the map extent for the lower 48 states, Alaska, or a custom target. The zoom tool (box with the "target") is activated by default when the interactive page is brought up, and the user can draw a box on the map to zoom to that extent. Zooming can also be done with the "zoom control" toggle or by centering the map on latitude and longitude

- Once the user has zoomed into an area of interest, they may use the query tool to gather information about a point, such as an observing station. To query a point of interest, select the query tool (the button with an "i" and an arrow) from the menu in the upper right dark blue bar. When the query tool is active, the cursor will change from a plus sign to an arrow. When the cursor is hovering over a point that can be queried, the cursor will change to a hand icon. The default query leads to time series plots of station information (described below). However, the pull-down menu in the query box next to the query tool can be used to query other elements such as flight lines, state and regional snowpack averages, basin snowpack averages and latest observations. The "latest observations" query option is activated to coincide with a selected "Latest Observation" from the "Select Physical Element" pull-down menu in the upper right-hand corner of the page.

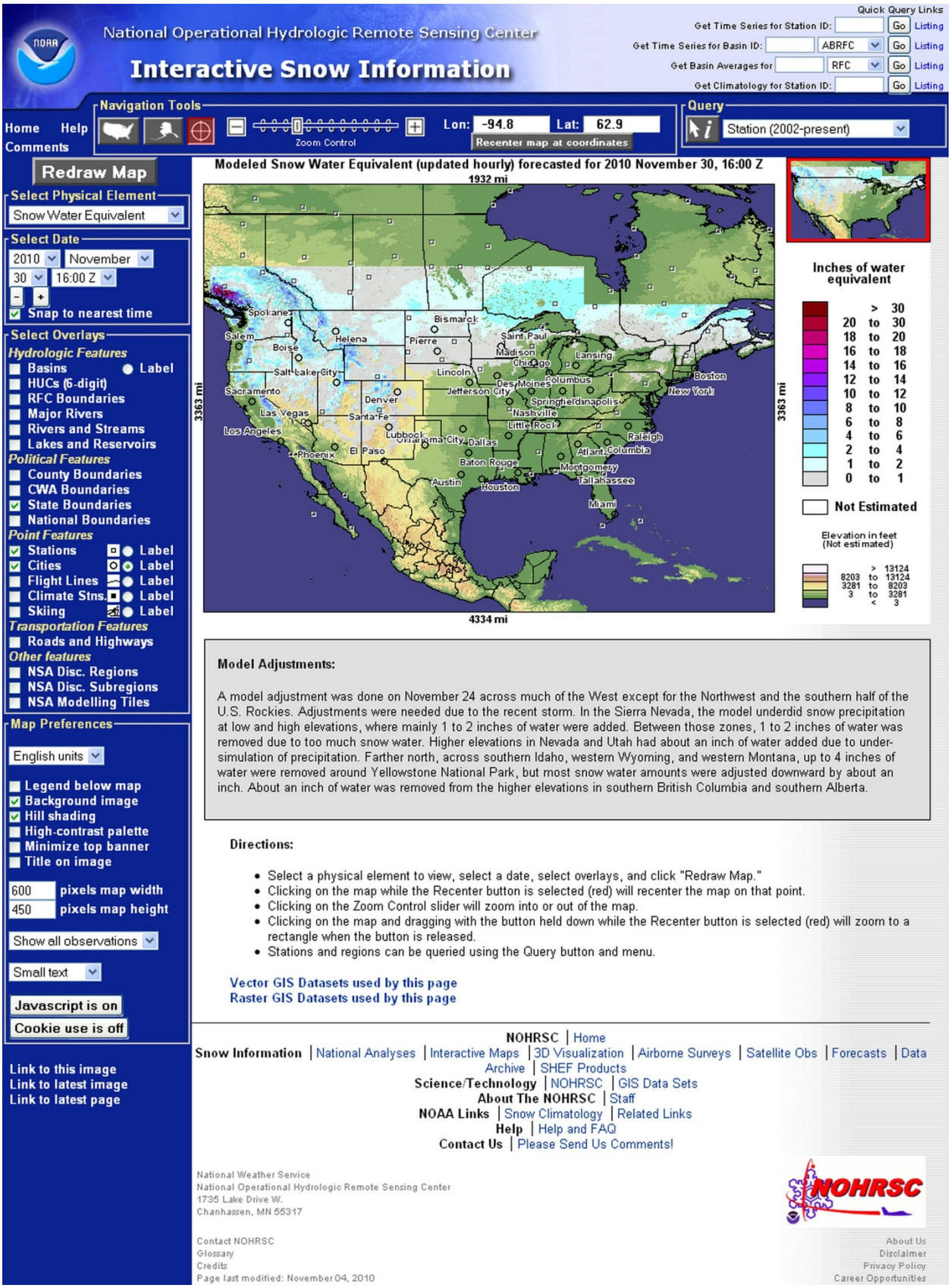

Figure 18. Initial display for Interactive Snow Information interface.

- The "Redraw Map" button can be clicked on at any time when a new physical element or overlay is chosen for display. The map will not refresh automatically.

- A series of "Link to…" options which allows the user to bring up their area and most recent element of interest whenever they visit the page using a bookmark. A user can set up this customized link by zooming in on a desired area, highlighting a physical element of interest (e.g. snow water equivalent), clicking on the "Link to latest page" option, and then making the new page a bookmark in their browser.

- At the very bottom of the dark blue margin on the left hand side is a series of "Link to…" options. If the user wishes to zoom into an area of interest and highlight a physical element of interest (e.g. snow water equivalent), they can click on the "Link to latest page" option and make the new page a bookmark in their browser. This allows the user to bring up their area and most recent element of interest whenever they visit the bookmarked page.

Time-series plots

- Once the user selects an observing station using the query tool, a page with time-series plots will appear. The user can select varying dates of interest at the top of the page. A user can also query a station by entering its station ID in the "Quick Query Links" box in the upper right corner of the Interactive page. A list of stations and their IDs can be obtained by clicking on the "Listing" option to the right of the query box.

- The time-series plots depict both modeled and observed snow information at a station. These plots include snow depth, snow water equivalent, snowpack temperature, snowpack density, surface snow sublimation and blowing snow sublimation. Station time series pages also include modeled and observed meteorological parameters such as air temperature, precipitation (snow and non-snow), wind speed, snow surface radiation fluxes and snow surface energy exchanges (click here to view a sample time-series plot).

- All data displayed in the time-series plots are available in tabular format and can be downloaded as a .csv file. Under the date range box, there is a pull-down menu that displays "All Images" as its default and is used to access individual plots, tabular data or .csv files. To change units from Metric to English, select the "Units" drop down menu.

- Time-series plots and associated text files for NWS River Forecast Center basin snow characteristics such as average snow depth, average snow water equivalent and percent snow cover can be obtained by using the "Get Time Series for Basin ID" option under the "Quick Query Links" in the upper right hand corner of the interactive page. Basin identifiers (ID) can be obtained by clicking on the "Listing" option to the right of each query option.

- The "Quick Query Links" also allow the user to search basins according to state, county, NWS County Warning Area (CWA), 6-digit US Geological Survey Hydrologic Unit Code (HUC-6) or NWS River Forecast Center. These options are particularly useful for water managers from groups other than the NWS.

Figure 19. Initial display for the National Snow Analysis 3D Interface.

Snow Information Heading – 3D Visualization

The 3D Visualization link of provides snow and snowpack data that can be projected onto three-dimensional images of terrain (Figure 19). Three dimensional viewing allows users to visualize elevation and terrain impacts on snow distribution and snow events.

The Snow Analyses Overlays displayed through this capability are three-dimensional views of the same data one can see in the NSA two-dimensional maps. These overlays are provided in .kmz (Keyhole Markup Language, Zipped) files, which allow geographic data sets to be viewed using Internet-based, three-dimensional Earth browsers (e.g., Google Earth). Instructions for how to download appropriate software and view the 3D overlays are found near the top of the page.

Snow Information Heading – Airborne Surveys

One of the key inputs to the National Snow Analysis is remotely-sensed snowpack data collected by NOAA aircraft. Airborne snow survey data collection is based on the relationship between gamma radiation emitted from the ground and the amount of water in the overlying snowpack. Naturally-occurring low level radiation is continually emitted from the soil from trace amounts of isotopes. Water, whether in the form of snow, ice or liquid, reduces (attenuates) the radiation that makes it into the open air. Sensitive detectors in the aircraft measure the radiation levels through the snow, compare the results from a previous snow-free flight and compute the amount of water contained in the snowpack. These flight lines are pre-selected to provide useful snowpack data to support NWS River Forecasting Centers.

The Airborne Surveys link brings up a web page with a photograph of the NOAA aircraft used to conduct airborne snow surveys and a short description of the program. Below the photograph is a table listing completed surveys for the current water year. At the bottom of the page is set of links providing access to the airborne snow survey schedule for the current snow accumulation period, aerial photos taken during surveys, an index and a map of flight lines, a link to soil moisture (snow-free) surveys, tables with historical snow survey information, a key to understanding Standard Hydrometeorological Exchange Format (SHEF) messages with airborne data, users guide for the Airborne Gamma Radiation Snow Survey Program (fairly technical), and information about the aircraft used in the collection of airborne snow data.

Snow Information Heading – Satellite Obs.

The Satellite Obs link provides access to graphical products depicting snow cover over the conterminous U.S., Alaska, and the Northern Hemisphere. These products are generated by the National Ice Center – an interagency center supported by NOAA, the U.S. Navy, and the U.S. Coast Guard.

Snow Information Heading – Forecasts

The Forecasts link provides access to numerous short- to long-term snow forecast products issued by entities outside the NOHRSC. The 3D Snowfall Probability Forecasts are derived from two-dimensional Weather Prediction Center (WPC) data and have been reformatted by the NOHRSC to produce 3D files. Instructions for viewing the 3D files are directly above the file links. The rest of the products on this page, such as nationwide watches and warnings and river flood conditions, are produced by NOAA entities other than the NOHRSC.

Snow Information Heading – Data Archive

The Data Archive link provides access to past grid-based daily output from the SNODAS model archived at the National Snow and Ice Data Center. Documentation and instructions on how to use the archive are provided, and data is accessed via FTP.

Snow Information Heading – SHEF Products

The SHEF Products link provides access to text products containing basin averages for one of seven snowpack-related variables, encoded in SHEF, for any user-selected date and time. The products are produced for basins within each NWS River Forecast Center domain. The seven simulate snowpack-related variables are: snow water equivalent, basin snow-covered area, average snowpack temperature, snow melt, blowing snow sublimation, snow depth and snow-pack surface sublimation. This product is primarily intended for NWS River Forecast Centers, but it is also made available to the public through this link. The SHEF Products display includes links which also allow users generate lists of Observation stations by WFO, CoCoRaHS station identifiers, and Stations with unknown metadata.

Observations Near Heading

This feature allows the user to request, for any city and state, the five closest observations of recent snowfall, snow depth, snow water equivalent, and total precipitation. The "Observations near" box will bring up a web page where the user can select a new location, time, date, year and English or metric units (click here for an example).

Science/Technology Heading - NOHRSC

The NOHRSC link brings up a mission statement for the NOHRSC and an overview of its functions. Following these are lists of documents and publications covering various aspects of the NOHRSC's operations. For an in-depth overview of the SNODAS model, refer to "NOAA's National Snow Analysis: Western Snow Conference, 2006 April" under the heading "NOAA's National Snow Analysis (NSA)."

Science/Technology Heading – GIS Data Sets

The GIS Data Sets link brings up several tables listing geographic information system (GIS) files and instructions for downloading and decompressing the files. Available datasets include: (1) basin boundaries for each NWS river forecast center area, (2) datasets that are used on the NOHRSC interactive web page, and (3) rivers and streams in each of the NWS River Forecast Center regions.

Science/Technology Heading – Special Purpose Imagery

The Special Purpose Imagery link brings up thumbnails for various images created for special projects. These images, usually satellite-derived, are used to support NWS River Forecast Center operations, particularly during flood events.

Other Links on National Snow Analysis Page

On the bottom of the dark blue margin on the left side of the home page, links are provided to: (1) the National Operational Hydrologic Remote Sensing Center staff directory, (2) information on snow climatology and other snow resources, (3) the websites of related NWS offices and

centers, NOAA centers, and external data providers, (4) a menu for obtaining help on using key features of the National Snow Analysis web pages (including frequently asked questions), and (5) a menu enabling users to submit comments.