



## Colorado's Flood Decision Support System (Phase 1)

### Executive Summary

The Colorado Water Conservation Board (CWCB) partnered with Riverside Technology, inc. (Riverside) to develop a Flood Decision Support System (Flood DSS) for the State of Colorado.

The Flood DSS provides a clearinghouse of flood hazard information for users within the CWCB (i.e., the Watershed and Flood Protection Section) and external stakeholders (e.g., developers, the insurance industry, government agencies, and the public). Data layers that show special flood hazard zone delineations, historical flood locations, and wildfire burn areas help users identify locations with elevated flood risks. Critical facilities data can be used to determine whether important infrastructure is at risk.

Weather and flood outlook data are supplied for emergency managers to assess the potential for rainfall and snowmelt flooding. These data include observed and forecasted rainfall, snowpack conditions, observed air temperatures, flood warnings, and high streamflow alerts.

The Flood DSS also provides a repository for supplemental information to support activities related to flood risk, such as weather modification and watershed restoration.

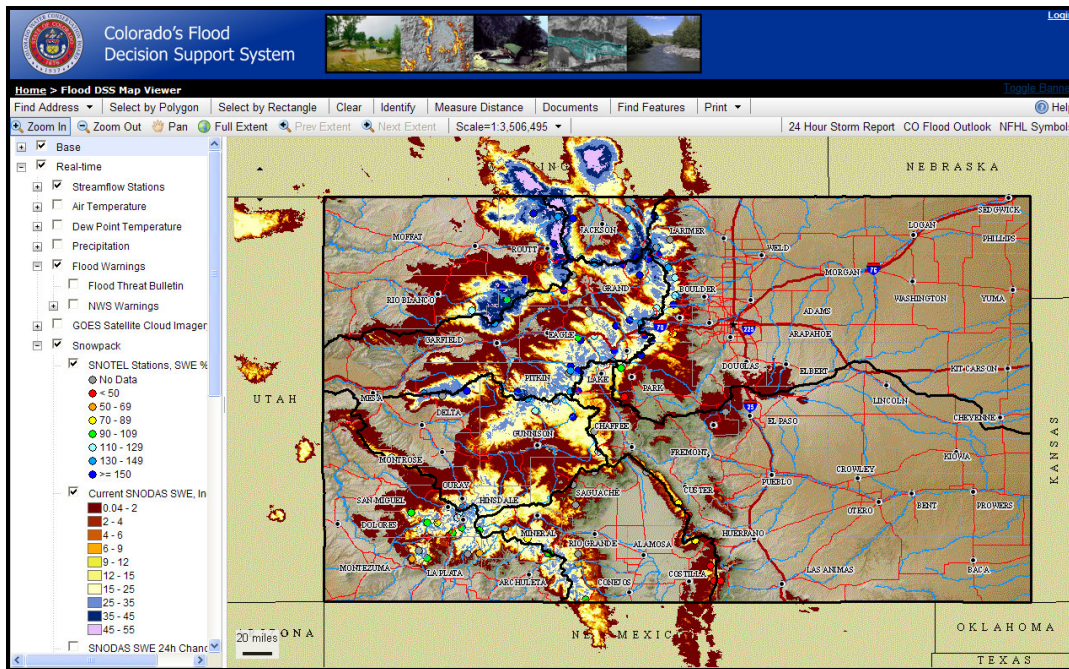
The Flood DSS facilitates data access, display, interpretation, and decision-making to help users focus resources on high risk areas. The objectives for the development of the Flood DSS under Phase 1 were to:

- Implement a web-based mapping system that organizes and disseminates flood-related data from multiple sources.
- Provide links that allow spatial and non-spatial data to be accessed simultaneously, for example from the CWCB's Laserfiche document system.

The Flood DSS is a collection of websites that are accessible at <http://flooddss.state.co.us>.

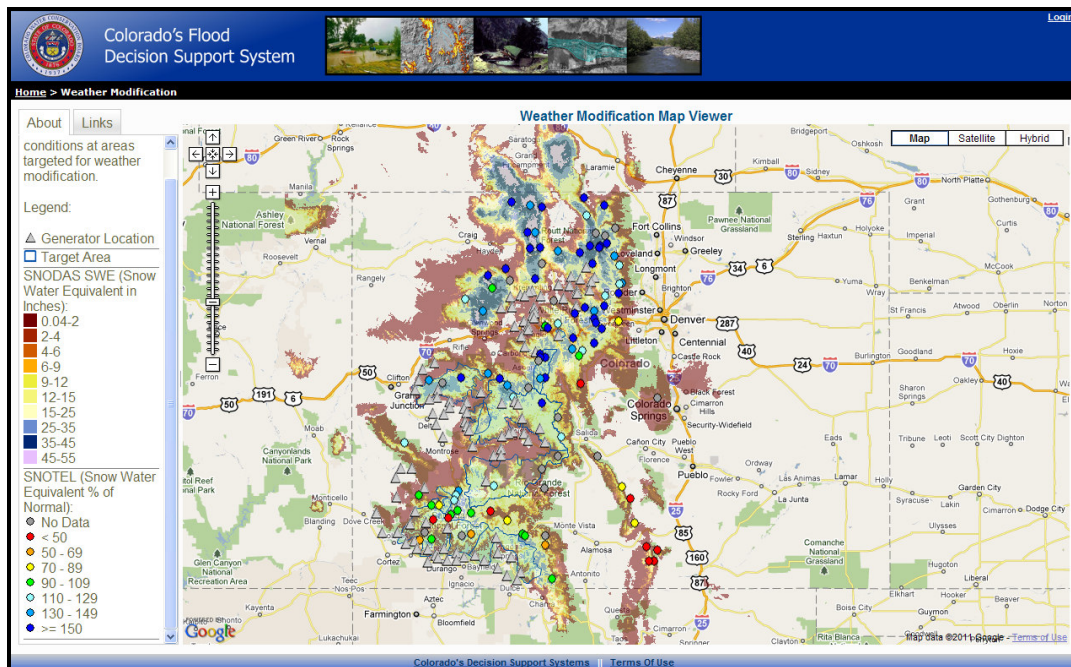
- The **Flood DSS Map Viewer** is an ArcGIS Server application that includes all data layers, links to documents in Laserfiche, and tools similar to those available in desktop GIS applications. Users can zoom to their area of interest and turn data layers on and off based on their needs. The data layers are organized into thematic components such as real-time weather and flood outlook, floodplain boundaries, historical floods, weather modification, watershed restoration, hazards and planning, National Flood Insurance Program, and local community data.

The Flood DSS Map Viewer is intended as a “power” site for users with GIS experience. The website supports numerous use cases, such as assessing the flood outlook based on real-time weather conditions, identifying critical facilities located in special flood hazard areas, reviewing historical flood information, etc. Most of the data layers are publicly available; however, a portion of the site is password-protected to provide community officials with access to restricted information such as streamflow alerts, dam locations, and draft floodplain delineations. The Map Viewer, which is shown in **Figure 1**, can be accessed at <http://flooddss.state.co.us/Viewer.aspx>.



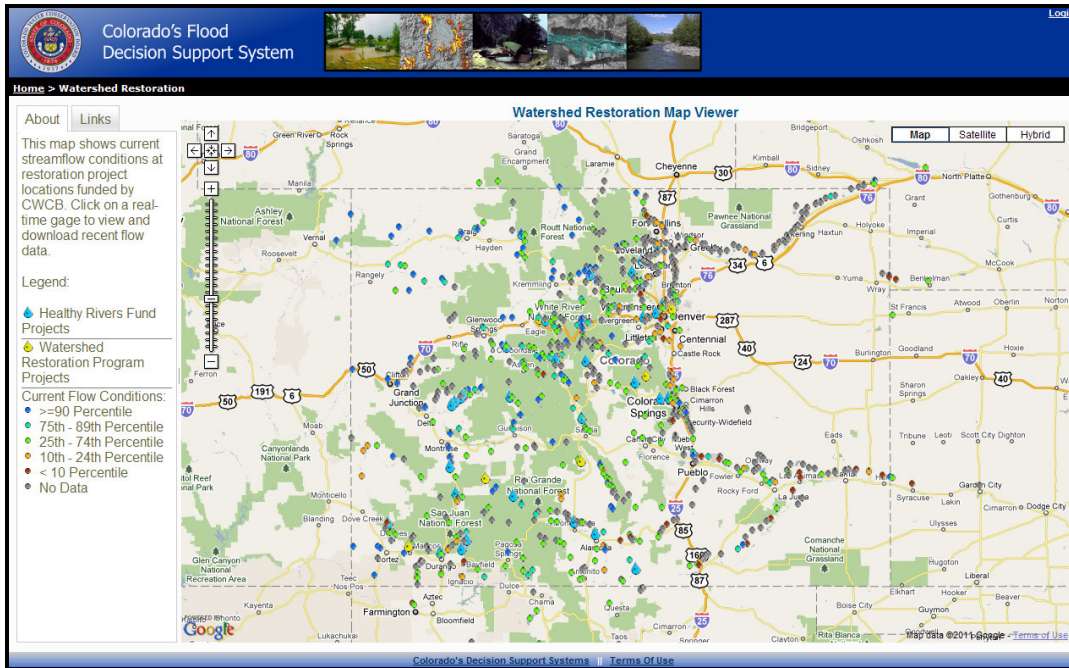
**Figure 1. Flood DSS Map Viewer**

- The **Weather Modification** website was developed to allow users to assess whether cloud seeding activities can be activated based on snowpack conditions. The website includes gridded snowpack estimates, point snow observations, generator locations, and target areas. The Weather Modification website, shown in **Figure 2**, can be accessed at:  
<http://flooddss.state.co.us/pages/WeatherModification.aspx>.



**Figure 2. Weather Modification Website**

- The **Watershed Restoration** website was developed to allow users to identify projects funded by the CWCB and to assess streamflow conditions near restoration projects. The Watershed Restoration website, shown in **Figure 3**, can be accessed at <http://flooddss.state.co.us/pages/WatershedRestoration.aspx>.



**Figure 3. Watershed Restoration Website**

- The **Additional Resources** website provides links to other flood-related data sources. This website can be accessed at <http://flooddss.state.co.us/pages/AdditionalResources.aspx>.

The Phase 1 scope of work was accomplished as a result of the following activities:

- Project Kickoff Meeting.** At the beginning of the project, a kickoff meeting was held to discuss data collection, data available from the CWCB, and technology solutions. **Attachment 1** contains a memorandum that summarizes the project kickoff meeting.
- User Needs Assessment.** Riverside performed a user needs assessment to identify data sources and use cases for the Flood DSS. Riverside conducted interviews with six staff members in the Watershed and Flood Protection Section of the CWCB and 14 external stakeholders. **Attachment 2** contains a summary of the user needs assessment.
- Evaluate Alternative Technologies.** The Flood DSS websites are administered by the CWCB and hosted by the Office of Information Technology in the Colorado Department of Natural Resources (DNR). Riverside and the CWCB worked to select technologies that are cost-effective, consistent with the DNR infrastructure, and can support the Flood DSS requirements. The Flood DSS Map Viewer was developed using ArcGIS Server and the ArcGIS JavaScript API Web Browser Client. **Attachment 3** contains a memorandum that summarizes the advantages and disadvantages of the technologies that were evaluated.
- System Development.** A large portion of the effort in the Phase 1 project entailed building the websites and the Map Viewer, developing scripted processes to download and manipulate data in



real-time, and implementing tools and features to make the websites usable.

- **Data Inventory.** Riverside and the CWCB selected data for inclusion in the Flood DSS based on user needs, data availability, integration effort, and project resources. A data inventory summarizes relevant attributes (e.g., format, source, update frequency, coordinate system) that CWCB will need to maintain the system. **Attachment 4** contains the memorandum and data inventory submitted as part of this effort.
- **Statewide Data Collection.** Riverside collected most of the statewide data from the CWCB, the Colorado Division of Water Resources (DWR), and federal agencies such as the Federal Emergency Management Agency and the National Oceanic and Atmospheric Administration. Data that are included in the Flood DSS but produced by other agencies are updated in the system with an appropriate frequency to ensure the data are current.
- **County Data Collection.** As part of the Phase 1 project, State, County, and local GIS coordinators were contacted by AMEC to acquire local flood hazard data that were then organized in the Flood DSS by county. Data were provided for 38 of Colorado's 64 counties. The Flood DSS administrator will continue to add and update the system as local data become available.
- **Integration of Real-Time Streamflow and Alerts Data.** The DWR provides real-time streamflows, high flow and rising rate-of-change alerts, and hydrograph plots using the Satellite Monitoring System (SMS). The streamflow and alert data were incorporated into the Flood DSS and are updated every 15 minutes. The Flood DSS links to hydrograph plots hosted on the DWR website. **Attachment 5** contains a memorandum that summarizes the requirements for incorporating the real-time streamflow and alert data from the SMS into the Flood DSS.
- **Automate Flood Outlook, Snow Data Assimilation System (SNODAS), and Snowpack Telemetry (SNOTEL) Data Processing and Management.** The snowpack and flood outlook products in the Flood DSS are automatically updated on a daily basis. The CWCB's Flood Threat Bulletin and 24-Hour Flood Outlook products are produced during the flood season from May 1 through September 30. Snowpack observations from SNOTEL stations and gridded snowpack estimates from SNODAS are available throughout the year.
- **Data Quality Assessment and Utility of Data for Web Serving.** Riverside evaluated all data to ensure the spatial properties were reasonable, that critical attributes were populated and clearly named, and that metadata were provided.
- **Data Processing.** The data were prepared for publishing to map services by projecting, symbolizing, and organizing the data into suitable groupings. Scale-dependent layer visibility and labeling were defined as appropriate. The datasets were grouped into map documents that serve as the map services for the Flood DSS websites.
- **Implement Access to Non-spatial Data.** The Additional Resources website provides links to external websites that provide useful flood hazard summaries and data products. **Attachment 6** contains a memorandum that lists the websites on the Additional Resources website.
- **Implement Links to Laserfiche Data.** A feature was added to the Flood DSS Map Viewer to assist users in finding and accessing documents in the State's Laserfiche system.
- **Installation and Testing.** Riverside maintains a development and testing environment with development and production servers. System updates and testing were conducted on the development machine before deploying to the production machine, ensuring that the production machine remains stable. The final Flood DSS websites were installed on the DNR server.



- **Training and Documentation.** Riverside provided training on the Flood DSS for the CWCB staff members. In addition, the CWCB and Riverside provided system demonstrations for conference attendees at the 2010 Annual Conference for the Colorado Association of Stormwater and Floodplain Managers (CASFM). User documentation is available within the Flood DSS Map Viewer. **Attachment 7** contains the Administrator's Manual that was developed to help the Flood DSS system administrator configure and maintain the system.
- **System Evaluation.** The CWCB reviewed the Flood DSS at three interim project milestones before the websites were deployed on the DNR server.
- **Project Management.** Riverside provided the CWCB with monthly status reports that were discussed during the monthly project status calls. Internally, Riverside conducted monthly quality assurance meetings and tracked budget, schedule, and progress to ensure successful project execution.

At the completion of Phase 1, the Flood DSS is a fully operational system that meets the requirements defined during the project. The system provides a clearinghouse of flood hazard data from local, state, and federal agencies; access to spatial and non-spatial data in one framework; and weather and flood outlook data that are updated on time scales of 15 minutes to one day, keeping users informed on the flooding potential across the state. **Attachment 8** contains a summary of recommendations for potential system enhancements.

#### **Attachments**

- Attachment 1: Task 1 Project Kickoff Memorandum
- Attachment 2: Task 2 User Needs Assessment Memorandum
- Attachment 3: Task 3 Evaluate Alternative Technologies Memorandum
- Attachment 4: Task 4 Data Inventory Memorandum and Interim Data Inventory
- Attachment 5: Task 6.1 and Task 6.3 Real-Time Streamflow and Alerts Memorandum
- Attachment 6: Task 7 Non-Spatial Data Needs Memorandum
- Attachment 7: Administrator's Manual (Version 1.1.0) and Final Data Inventory
- Attachment 8: Recommendations for Potential Enhancements Memorandum