

Colorado High-Hazard Dam Release - Downstream Floodplain Impacts Database and Tools

Improving information sharing and raising awareness to enhance dam safety and community resilience.

Background

Dams provide essential services that are often unseen to many: storing water for household use; irrigation; energy production; recreation; and minimizing flooding impacts. However, large amounts of water may be released even when dams are functioning properly due to intense rainfall, rapid snowmelt, or other unanticipated circumstances. This can result in flooding to downstream communities.

Recent flooding events in Colorado in 2013 and 2015, and nationwide in 2017, have highlighted how excessive reservoir inflows (the amount of water entering a reservoir) can impact dam spillways flows (flows designed to control the release of water to protect dam structures and prevent overtopping). In particular, excessive inflows can lead to dams exceeding normal spillway flow rates, which may require the controlled releases of water to lower reservoir levels. In some cases, emergency actions have been necessary to address hazardous conditions that developed in the channels and floodplains downstream of the dams.

Sectors

- Infrastructure
- Watershed and Natural Resources

Partners

- [Colorado Dam Safety/Colorado Department of Natural Resources](#)
- [Gannett Fleming](#)
- [Clear Creek County Emergency Management Services](#)



Spillway overflow at the Button Rock Dam

The Challenge

Although all high-hazard dams in Colorado have dam failure inundation maps to outline flooding limits for dam failures, no mapping exists for the range of releases that might be anticipated to occur during flooding events. Providing emergency managers and floodplain managers with the tools to assess a range of scenarios from dam releases would enable them to begin addressing the risks certain areas face from such failures.

Based on their experiences with previous annual flooding during spring runoff, [Colorado Dam Safety](#) (part of the [Colorado Department of Natural Resources](#)) and a few local jurisdictions identified some isolated problem areas with constricted stream channels immediately downstream of dams in developed and urban areas. While flood impacts downstream of floods are less likely in rural areas, the potential for flooding there is generally unknown due to a lack of available data. To identify and prioritize alternative floodplain mitigation and emergency preparedness solutions, Colorado Dam Safety (CDS) needed to better understand where communities are at risk from dam releases.

Innovative Solution

To address this need, the project team developed the *Colorado High-Hazard Dam Release - Downstream Floodplain Impacts Database and Ranking Tool*. The tool can be used to support public awareness, planning, and emergency preparedness activities, as well as during emergency response situations involving high hazard dams throughout Colorado. CDS is the first state dam safety program in the nation to systematically evaluate their portfolio of 400 high-hazards dams related to operational and flood release capabilities.

Colorado Division of Water Resources High Hazard Dam Release - Downstream Floodplain Impacts Study <small>Revision Date: 9/27/2017</small>		General Info		Spillways	Outlet Works	Dam	Streamflow Statistics at Dam	Ranking	Consequence Analysis	FEMA	Hydraulic Analysis	
Expand >		Expand >		Expand >	Expand >	Expand >	Expand >	Expand >	Expand >	Expand >	Expand >	
Dam Name	Dam ID	NID ID	kmz	Controlled Capacity (cfs)	Outlet Capacity (cfs)	Total Max. Controlled Discharge (cfs)	Dam and/or Main Channel Drainage Area (mi ²)	Dam Not Considered	Composite Ranking	First Impacted Downstream Road kmz	FIS Profile	Hydraulic Analysis Performed:
RUETER HESS	080450	CO02949	Google Earth	648	594.7	1242.7	10.52		1	Google Earth	FIS Profile	
MAPLE GROVE	070219	CO00203	Google Earth	13365	102.0	13467.0	10.40		2	Google Earth	FIS Profile	X
BEAR CREEK	090112	CO00004	Google Earth	0	2000.0	2000.0	235.67		3	Google Earth	FIS Profile	X
CHATFIELD	080324	CO01281	Google Earth		8300.0	8300.0	3020.77		4	Google Earth	FIS Profile	X
KELLY ROAD DETENTION	020609	CO02345	Google Earth		690.0	690.0	10.65		5	Google Earth	FIS Profile	X
BLUNN	070302	CO00980	Google Earth		420.0	420.0	48.29		6	Google Earth	FIS Profile	X
STANDLEY LAKE	020326	CO00101	Google Earth		700.0	700.0	15.95		7	Google Earth	FIS Profile	X
RALSTON	070224	CO00205	Google Earth		650.0	650.0	46.41		8	Google Earth	FIS Profile	X
TRINIDAD	190122	CO00050	Google Earth		5500.0	5500.0	671.86		9	Google Earth	N/A	
SOUTH PLATTE RESERVOIR	080446	CO02858	Google Earth	0	110.0	110.0	0.30		10	Google Earth	FIS Profile	X
MONTGOMERY	230134	CO00372	Google Earth		1243.0	1243.0	7.84		11	Google Earth	No Profile	
CHERRY CREEK	080116	CO01280	Google Earth		8100.0	8100.0	385.67		12	Google Earth	FIS Profile	X
ANTERO	230102	CO00351	Google Earth		1800.0	1800.0	190.91		13	Google Earth	No Profile	
LOWER CABIN CREEK	070110	CO01240	Google Earth		549.0	549.0	13.65		14	Google Earth	FIS Profile	
HOLLY	080335	CO02214	Google Earth		195.0	195.0	2.05		15	Google Earth	FIS Profile	
LEGGETT & HILLCREST	060131	CO00232	Google Earth		385.0	385.0	1.52		16	Google Earth	FIS Profile	X
DILLON	360104	CO00875	Google Earth		4400.0	4400.0	334.09		17	Google Earth	No Profile	

The database contains information for private and public (i.e., federally-owned) high-hazard dams, and provides a tool for screening and ranking risk levels. The database allows users to evaluate dams based on the following categories:

- General dam information (e.g. name, location, lat/long coordinates, county, stream source);
- Spillway capacity;
- Outlet capacity;
- Total controlled release capability;
- Stream flow;
- Ranking of the hazard potential;
- Consequence analysis (first impacted downstream roads, structures)
- FEMA Profile; and
- Hydraulic analysis

This information can be useful to raise awareness of risk issues for State and local planners in flood hazard identification and mitigation. Floodplain and emergency managers can use this information to assess their risks related to dam releases, and empower them to make decisions on where additional detailed analysis of safe channel capacity should be done. It will also be useful for State and local emergency managers and first responders in preparedness and mitigation activities, and in executing an effective emergency response to dam safety incidents and operations, including outlet and spillway releases at high-hazard dams.

A Unique Approach


In order to understand potential impacts of these conditions statewide, the project team (engineers from CDS and the consulting firm Gannett Fleming) conducted a screening-level study that maximized the use of existing Colorado dam database information, readily-available [USGS Streamstats](#) information, FEMA's [Flood Insurance Studies](#), and FEMA's [National Flood Hazard Layer](#). The data from these sources provided comparisons of naturally occurring flows versus natural flows plus additional flows from dam releases. The project team developed criteria to rank the severity of the conditions to focus attention on potential areas of concern and prioritize future activities.

With this criteria, the project team performed hydraulic analyses on 27 high-hazard dams in Colorado. The analyses compared the estimated safe channel capacity (the ability to handle discharge without causing flooding) of the downstream channel below these dams to the maximum controlled discharge capacities of the dams outlets and gated spillways. The project team used existing high-resolution LiDAR data in a sophisticated 2D modeling environment. Google Earth was linked into the database to enable rapid visualization of the results. The resulting visual interface allows for easy interpretation of the comparisons and possible flooding extents.

Outcomes

This database and ranking tool provides a screening-level assessment of the potential for hazardous conditions downstream of high hazard-dams throughout Colorado. It provides a ranking of high-hazard dams where there is either a high, moderate, or low likelihood of the existence of dangerous conditions created by dam and reservoir release operations simultaneously with naturally-occurring flood conditions.

The small set of detailed hydraulic analyses performed show the utility of 2D modeling of channels downstream of the dams. The visualization products of this method can be used to demonstrate to decision makers where potential problems exist and where focused mitigation and/or emergency preparedness activities are warranted.




Colorado Division of Water Resources
High Hazard Dam Release
Downstream Floodplain Impacts Study

MAPLE GROVE

DAM ID	070219	Go to Google Earth
NID ID	CO00203	Latitude 39.756
County	JEFFERSON	Longitude -105.138
Stream	LENA GULCH	

Dam Drainage Area, DA (mi ²)	10.40	Outlet Works Capacity (cfs)	102
100-Yr StreamStats Discharge (Q ₁₀₀) (cfs)	2370	Total Maximum Controlled Discharge, Q _{cont} (cfs)	13467
Total Spillway Capacity, Q _{sw} (cfs)	13365		



Ranking Summary

R1: DA & Total Max. Controlled Discharge	4	R4: Q _{sw} & Total Spillway Capacity	175
R2: Q ₁₀₀ & Total Max. Controlled Discharge	4	R5: Total Max. Controlled Discharge	4
R3: Distance To Downstream Town	1	R6: Total Spillway Capacity	76

Composite Ranking 2 HIGH *Rankings reported out of 418 total dams*

Consequence Analysis

Population at Risk (PAR)	2557
Social Vulnerability Index (SVI)	-1.4 MODERATE

Estimated first impacted downstream road [View in Google Earth](#)
Estimated first impacted downstream structure [View in Google Earth](#) page 2

Hydraulic Analysis Summary

Dam Name	MAPLE GROVE
Dam ID	070219
Safe Channel Capacity (cfs)	350

Sample page from the High Hazard Dam Release Tool

Next Steps

The project plans to fully deploy the tool to public agencies responsible for floodplain management and emergency response to flooding. The rankings can enable agencies to set priorities for future detailed studies of safe channel capacity, quantify controlled and uncontrolled release capabilities and impacts, and develop mitigation and preparedness strategies. Additional detailed hydraulic analyses needs to be performed on all of the dams ranked as High Risk.

As potential problem areas are identified, programs can developed to disseminate potential hazard information to those responsible for infrastructure development, community awareness, and resiliency planning. Dam owners can and should be involved to learn of the potential risk of operation of their controlled outlets and spillways. Additional communication can be used as a basis for planning and coordination of reservoir operations at the safest times possible. In addition, dam owners can use this information to prioritize security and facility hardening measures to ensure against unintentional or malicious operation of their facilities. The current database should be integrated with future efforts to reduce the risk of hazardous conditions downstream of high-hazard dams.

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