Denver's Forgotten Flood
The Geomorphologic Impacts of the 1933 Castlewood Dam Failure

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IN 1933, AFTER FORTY-THREE years of controversy and disquiet, the 1890s Castlewood Dam collapsed, causing one of the worst floods ever reported on Cherry Creek in Denver, Colorado. However, despite the colossal damages and resultant economic woes, the flood and its profound impacts have remained widely under-researched, and, for many, forgotten. Historic reports outline the implications in the city and several engineering reports expose the cause but nothing of the dramatic changes in canyon or the people. How did this event alter the canyon? Not only the channel shape and scoured walls but also, and more profoundly, the geomorphology. In what capacity did the 1933 Castlewood Dam failure impact the natural progression of erosion, deposition, and geomorphology in Castlewood Canyon?

Through a compilation of existing data, collection of new field data, and technical analyses, this study seeks a greater understanding of the overall geomorphological implications of the great 1933 flood. There are two major components: tracking the erosion and deposition of major masonry flood debris (i.e., structural clasts or blocks from the dam itself) and estimating the total sediment displacement via GPS and Laser Rangefinder-generated cross sections and geologic comparisons. The objective rests in producing an idea of just how this event resulted in rapid, but long-term changes in the landscape.

Castlewood Dam History

Castlewood Dam was built in 1890 by the Denver Water Storage Company partnered with the Denver Land and Water Company, a committee of landowners who were trying to sell large portions of the surrounding farmland. The purpose was to provide a reliable water source to entice settlers and increase property value, as the soil is fertile but there wasn't enough natural water for irrigation farming.[1] The dam was a rock fill design composed of two separate walls, a straight wall on the reservoir side and an angled stepped wall on the downstream side, with gravel (i.e., rock fill) and concrete poured in between.[2] Without the aid of modern technology, the dam, completed in only eleven months, was built entirely by hand and mule with Mr. A. M. Welles as designer and chief engineer. For such a rapid construction, the dam was impressive: over 183 meters across, 21 meters tall, and 15 meters deep at its base. Masonry stones were quarried from nearby cliffs and were primarily Castlerock Conglomerate. The reservoir had a maximum capacity of 6.4 million cubic meters, however, by the time the dam failed, reports claim it had silted in by nearly 50 percent.[3]

From the moment the dam began impounding any significant amount of water, it began to leak (Figure 1). Countless reports were filed by a number of government and private agencies ensuring the dam's safety but the dam's stability was publicly debated continuously until the day it failed. Local newspaper headlines ranged from "Castlewood Is Safe" (*Rocky Mountain News*–1896) to "Castlewood Dam Not Over-Strong: Engineer Ryan Doubts That It Can Withstand a Flood" (*The Denver Republican* — 1900) and other such contradictions were released nearly annually. Eventually, in 1900, A. M. Welles wrote a letter to *The Denver Post* newspaper defending his work:

> *"The Castlewood dam will never, in the life of any person now living, or in generations to come, break to an extent that will do any great damage either to itself or others from the volume of water impounded, and never in all time to the city of Denver."*[4]

Persistent controversy, along with various financial complications, spurred ownership of the Castlewood Dam to change eight times during its lifetime.[5] Each new owner would hire inspectors, release new reports, and continue advertising the surrounding irrigated farmland, all the while the safety concerns were neglected and the dam fell into disrepair.[5] Between 1912 and 1933 spikes in reservoir levels indicate twelve separate events that could have flooded the valley had the creek been left uncontrolled. Over time the weakened dam, led to a myriad of quick fixes and modifications. In May 1897, high lake waters and foundation settling caused multiple horizontal cracks 5–10 cm deep, requiring the reservoir to be completely drained for repairs.[6] Then, in 1899, massive amounts of earth were placed against the upstream face of the dam, in hopes of reinforcing the structure and sealing the infamous leak.[7] Unfortunately, the attempt was unsuccessful and the dam continued to seep for the next three decades.

Then, on the night of August 3, 1933, the Castlewood Dam gave credence to the “sensationalist prattle” Welles had so vocally detested in his 1900s letter. After several days of steady rain, a cloudburst over the Cherry Creek drainage basin pummeled parts of the 450 square km region with 8–23 cm of rain within a matter of hours and massive amounts of water flowed into the Castlewood Reservoir. Later reports estimate the peak inflow of 100 cubic meters per second (m^3/s) into the reservoir.[8] In an interview with Colorado State Engineer M. C. Hinderlider, the caretaker who lived near the dam, Hugh E. Paine, recounts the unprecedented inflow: “At 11:15 o’clock the water was [1.8 m] below the spillway. . . . By midnight the water had raised to the top of the dam [and] by 12:15, a torrent of water was pouring over and through the dam. . . .” Later in the same report, Hinderlider extrapolated the startling discharge overtopping the dam: “The dam was overtopped the full length thereof to a depth of [0.3 m], which caused a discharge thru the spillway of a depth of [1.5 m], estimated to have been [85 m^3/s]. At the same time the discharge of the remainder of the crest approximated [70 to 85 m^3/s] making the total flow from [155 to 170 m^3/s] over the dam.[9] The decrepit dam could not withstand the pressure and within 45 minutes the center gave way, sending an estimated 6.4 million cubic meters of water crashing downstream.[10] According to a 1933 report filed with the United States Department of the Interior, peak discharges were as high as 3,600 m^3/s at the dam, though this

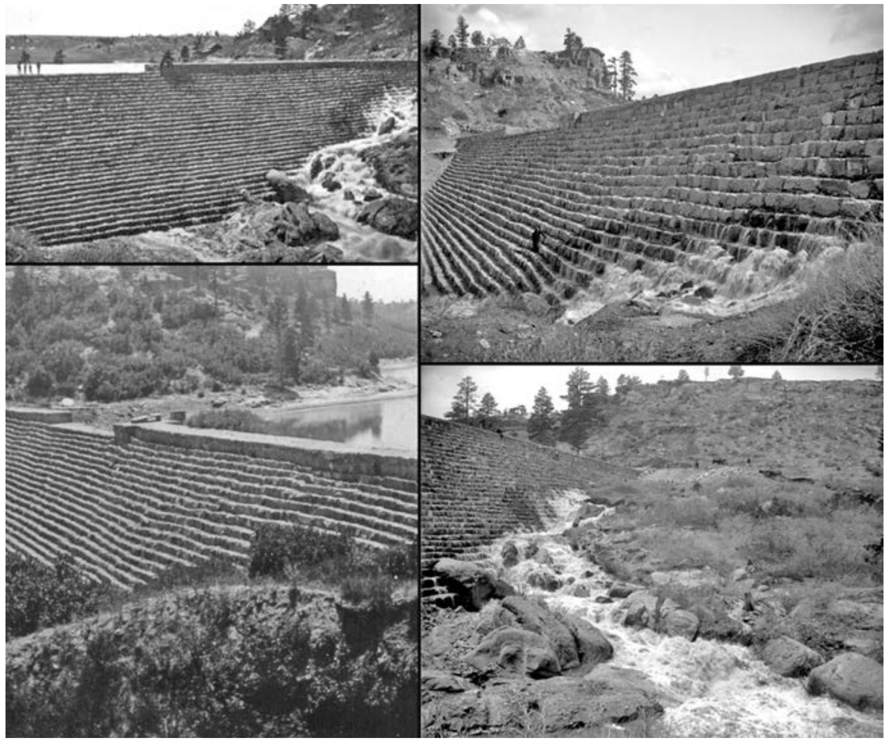

Figure 1. Dating 1890–1910, these images show the Castlewood Dam’s infamous leak with several men for scale. The dam seeped for the entire 43 years it was in use and was a great concern to those residing downstream. *Photos from the Colorado Historic Society and Castlewood Canyon State Park.*

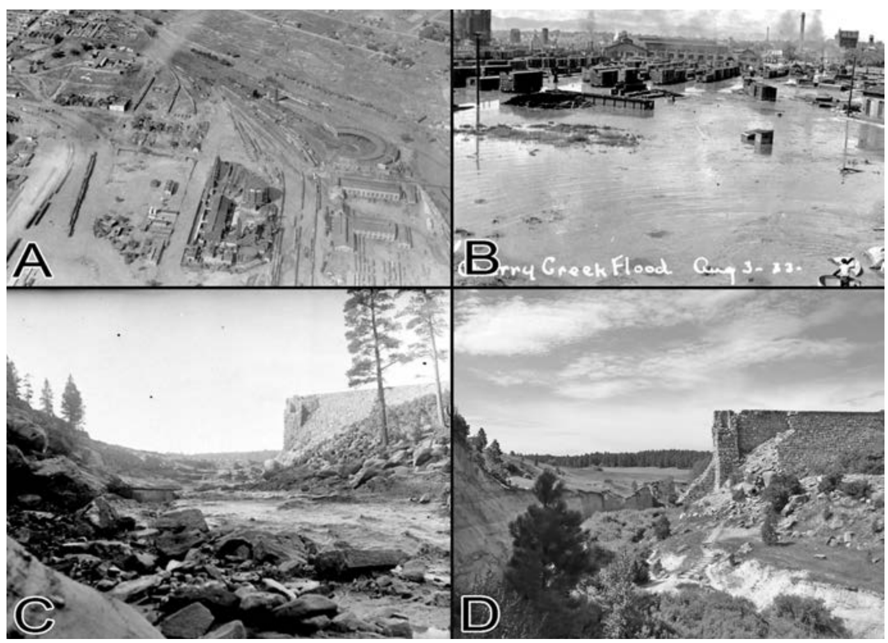

Figure 2. These images show the various impacts of the 1933 Castlewood Dam failure. Photo A, from the Colorado Historic Society, shows an aerial shot of Denver’s famous Union Station completely inundated. A little closer to the ground, photo B from the Denver Historical Society displays the flooded train yard. *Photo C, from the Colorado Historic Society, is the breached dam the day after the flood and photo D is the dam ruins today by Kaelin M. Groom.*

figure is contested,[11] 960 m^3/s at the Kenwood Dam site 37 km downstream, and by the time the flood waters reached Denver, 50 km downstream, it was still greater than 450 m^3/s, nearly double any subsequent flood on Cherry Creek at Denver.[12]

The sustained damages were extensive totaling $1.7 million in 1933 currency, nearly $30 million today.[13] Union Station, situated downtown, was beneath a meter of water, with the basement and baggage subways entirely inundated (figure 2). Several bridges were destroyed and 15th Street was inundated with 0.6 m of water.[14] Of the estimated losses, nearly $960,000 was suffered in the farmlands upstream of Denver and additional economic damages came from the loss of water supply to over 12 square km of the surrounding area.[15]

Multiple prior studies have been conducted at the dam site to determine to cause for the breach. Some claim there was a natural spring under the dam that weakened the foundation while others say the entire structure actually dislodged and shifted downstream 0.6 m before it failed.[16] The official cause, as reported by Colorado State Engineer H. C. Hinderlider, attributed the cause to "foundation percolation coupled with intense overtopping."[17] Despite being the largest recorded flood on the Cherry Creek and one of the most expensive in Denver history, little research, past or present, has addressed its lasting repercussions or geomorphologic impacts on the canyon itself. This study is the first to address such questions.

Physical Geography of Castlewood Canyon

Basic geologic structure. There are three primary geologic formations exposed in Castlewood Canyon. The oldest is the tuff-colored Dawson Arkose Sandstone (55 mya) often separated into the Upper and Lower Dawsons. This friable layer is mostly exposed downstream of the Castlewood Dam.[18] Above the Dawson there is the Wall Mountain Tuff, 37 mya. This rhyolite stratum varies in color from blues to pinks to greyish purples and can be found throughout the canyon, particularly as large clasts in the next geologic formation and caprock: the Castlerock Conglomerate (34 mya), lithified components of alluvial fans from the ancestral Rocky Mountains.[19]

Climate. As mid-latitude steppe (BSk Köppen classification), central Colorado enjoys a dry moderate climate. Throughout the year humidity remains relatively low with average annual precipitation of 43 cm and average annual snowfall of 148 cm. Temperatures range from an average of 30?C in July to -8?C in January.[20]

Slope. The stream gradient varies greatly throughout the canyon with an overall average is 0.0067 m/m. The area once covered by the old Castlewood Reservoir has a lower slope of 0.0037 m/m where the deeper canyon at and below The Falls is a greater 0.0134 m/m as derived from high-resolution 1.5 m interval hypsometric maps.

Vegetation. Within the northern most extent of the Palmer Divide, Castlewood Canyon is a hub of various biomes: Ponderosa pine savanna and Douglas fir woodland throughout the canyon, mixed foothill shrublands on the drier slopes, mixed and short grass prairies in the old reservoir, and wetlands along the creek. The most common species found within the study area are ponderosa pine, chokecherry and Gambel's oak.[21]

Paleoflood Investigations

The absence of pre-1933 channel geometry data limited the validity of before and after comparison so conventional paleoflood techniques were utilized. Though paleoflood hydrology and research usually focuses on prehistoric floods, its methods are also applicable toward historic floods,[22] as is the case with Castlewood Canyon. Spatial analysis of large debris deposition, and cross sections of flood terraces and gravel bars were conducted to gain greater understanding of the 1933 flood's behavior and erosive power. In the following sections both components will be expounded followed by analysis and discussions.

Site Selection

For the purpose of maintaining a relative consistency in variables (channel width, canyon dynamics, exposed geology, etc.), the scope of this study concentrated on the channel length (or reach) from at the Castlewood Dam ruins to the opening of the canyon, approximately 2.7 km downstream (figure 3). Once the flood reached the plains its behavior would have changed and previous methodology would no longer apply and any paleoflood evidence found upstream of the reservoir site would only pertain to natural floods and mute to the study of the dam failure. The area known as The Falls, roughly 0.8 km downstream of the dam, marks a significant change in the canyon. At this point there is evidence of turbulence and the downstream canyon becomes a deep ravine with little to no vegetation, large exposures of the Dawson Arkose Formation, and very distinct flood terraces with a number of large gravel bars. This becomes an important location for both debris distribution at and around The Falls and along the cross sectional portions of the terraces directly downstream.

Field Techniques

As this is exploratory research, no remotely-sensed data were available, so a number of field techniques were applied. The positions of debris and cross sections were recorded with a Trimble™ Juno SB® GPS unit with +/- 3 m accuracy and cross section

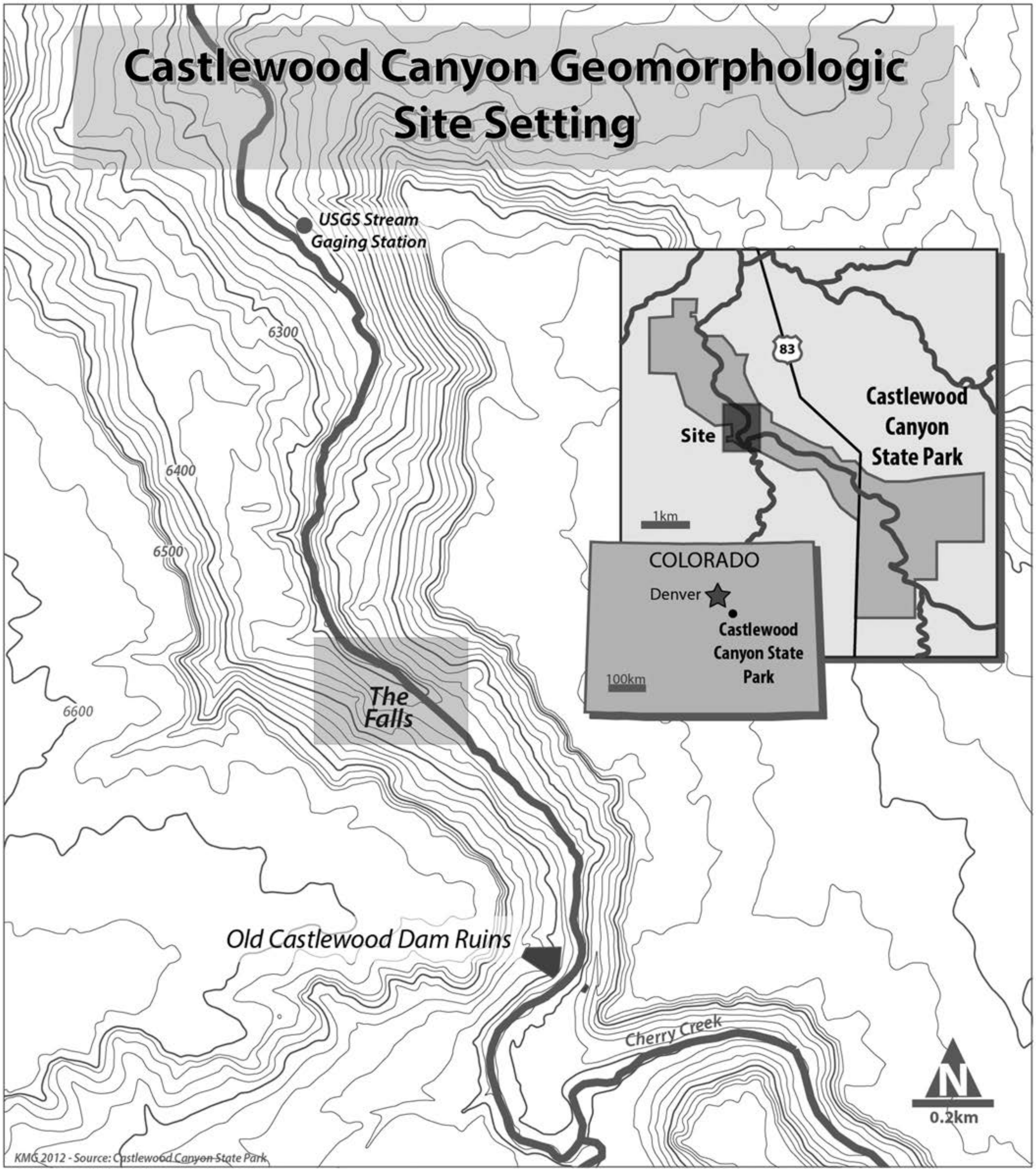

Figure 3. Map of the study area showing Castlewood Canyon State Park's location within the state of Colorado and the sites relevant to this research. *Kaelin M. Groom 2012.*

geometry was measured with a Laser Technology Inc.™ True Pulse 360R® laser rangefinder in conjunction with the GPS unit with +/- 1 ft accuracy. Once mapped, these data reveal an intriguing relationship.

Dam-cut blocks. Large and high-event floods, principally on higher gradient streams (0.003 m/m (0.17 degrees) or more), often transport large amounts of sediment and other debris causing the majority of damages sustained. In the case of Castlewood Canyon, the masonry blocks, or dressed stone, from the breached dam acted as powerful scouring tools as they were sent crashing through the canyon. Studying certain elements of these blocks by calculating how many were removed from the dam structure and analyzing spatial patterns of deposition can provide a greater understanding of the flood's behavior and its geomorphologic impacts. In the history of this canyon, this is the first study to address the debris of the flood, specifically the masonry blocks.

To study the boulders outside of the dam structure they must first be identified. Because they were extracted from local cliffs, geology alone is not enough, nor size and shape. Although the majority of hand-cut blocks are roughly 60 cm x50 cm x120 cm they were not symmetri-cal and linear bedding planes caused many of the boulders in the area to decay angularly. This creates some confusion as many preexisting boulders have the correct size and shape but have no other signs of identification and could possibly be naturally formed. For these reasons, all blocks

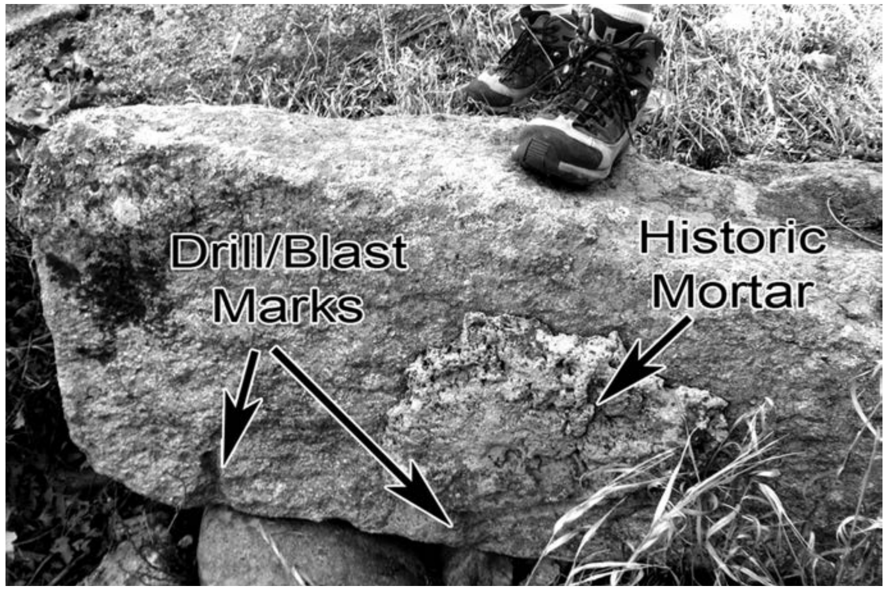

Figure 4: The identification of the masonry blocks through drill/blast marks and historic mortar. Many of the boulders near the ruined dam have both but further downstream the constant battery of the floodwaters detached the mortar and the drill marks become the more consistent indicator. *Photo by Kaelin M. Groom.*

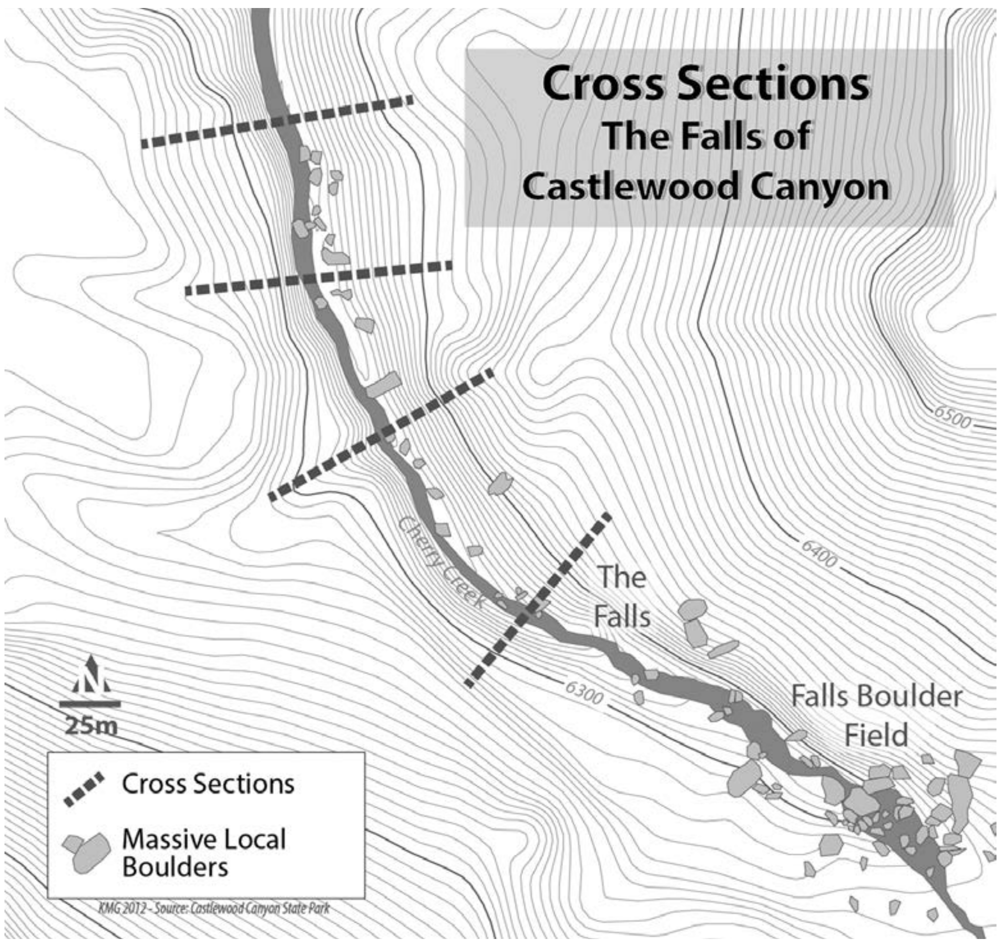

Figure 5: Map of the cross sections recorded directly downstream of the Falls shown with relative location to the Falls Boulder Field. *Kaelin M. Groom 2012.*

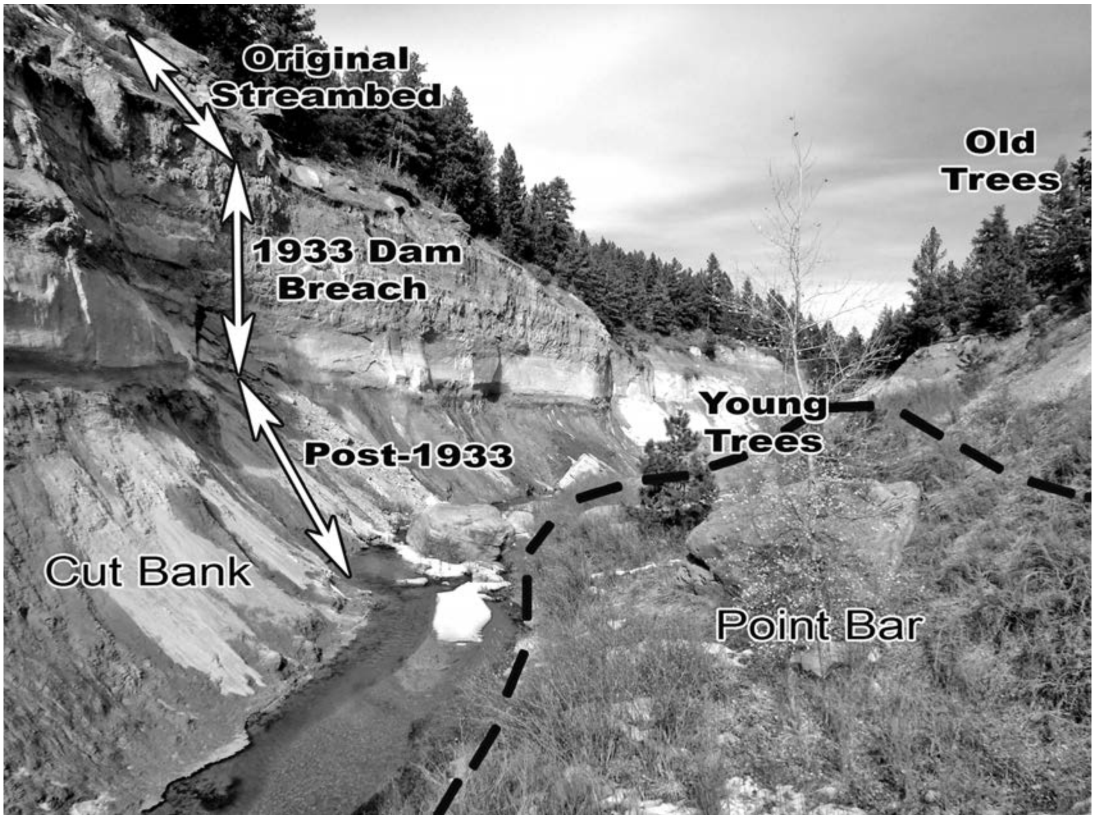

Figure 6: Image of the three terraces downstream of the dam. Note the slight undercutting at the base of the 1933 flood terrace denoting the vertical limit of subsequent floods. The distinct contrasts of tree sizes within and without the flood zone also serves as a high water mark. *Photo by Kaelin M. Groom.*

were identified in this study by isolating anthropogenic stone-dressing; specifically drill marks and historic mortar.

One method was locating blocks with drill scars, indicating that they were quarried. These drillholes are 4 cm wide half cylindrical marks cut from the edges of the stone into the center. They can be anywhere from 8 cm to 60 cm long and can be found on all sides of the block. These were verified by finding marks on clasts still part of the ruined dam as well as others downstream. However, due to the magnitude and debris contained in the flood, this method of identification becomes increasingly difficult farther downstream, as many suspected drill marks are battered and eroded beyond conclusive identification. Several boulders found over 3 km downstream have the right size, shape, and geology, but the edges have been so rounded any evidence of quarrying is negligible.

Another form of identification was the presence of historic mortar still attached to the boulders. Very distinct from the local geology, thin slabs of mortar are easily recognized. Unfortunately, much like the drill marks, this characteristic is only valid for a certain distance downstream before the erosive power of the flood debris detached the cement from the blocks. Many clasts close to the dam have both drill marks and attached mortar, verifying the method of identification, but downstream the drill marks are more reliable (figure 4).

Sediment displacement. Lack of high-resolution pre-flood channel geometry downstream from the Castlewood Dam necessitated GPS-generated cross sections. This is speculative, however conventional, and is only meant to derive estimated but valuable sums. The cross section element is primarily focused on the canyon directly below The Falls where flood terraces are most clearly seen. Volumes of sediment displaced per cross section were estimated and then averages were applied to the entire downstream canyon reach.

Distinct flood terraces, 1933 paleoflood debris deposits, and well-defined previously buried soil profiles made the lower canyon a unique study reach for obtaining cross sections. Three specific terraces can be identified: (i) the speculated original stream elevation, (ii) material displaced during the 1933 flood, and (iii) all subsequent erosion. Historic photographs and topographic maps support this assumption. Four cross sections were recorded roughly 15 meters apart to define the 60-meter study area (figure 5). Using the three levels, polygons were created to extrapolate the volume of displaced material coinciding with each erosional era: the pre-1933 flood and post-1933 geometry (figure 6).

Analysis

Dam Cut Block Spatial Analysis

Through the analyses of historic photographs (estimating number of

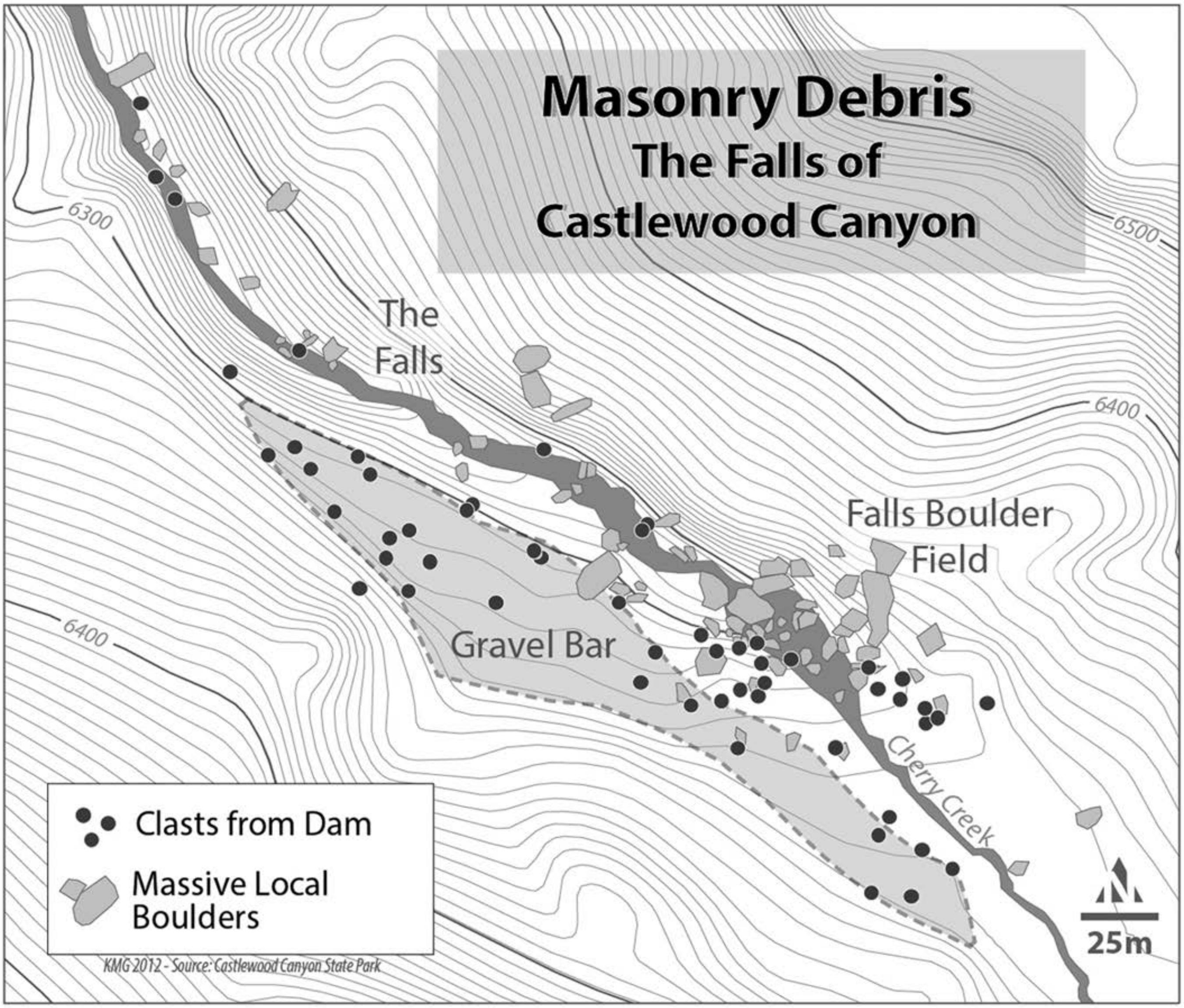

Figure 7: Map of flood debris and deposition in and around the Falls area. *Kaelin M.Groom 2012.*

cut blocks per row) and geometrically reverse engineering original blue prints it is extrapolated that the flood displaced approximately 7,900 boulders. This is roughly 60 percent of the entire dam structure and nearly the entire loose rock fill core. Averaging around 723 kg each (found through density analysis of smaller samples of the same material then applied to the masonry blocks), this means over 5.7 million kg of debris was moved during a single event, not counting massive quantities of the sediment built up behind the dam and in situ boulders downstream in the canyon. Because it is speculated that the dam failed nearly instantaneously, a hypothesis supported by large still-mortared sections (roughly 1.5 m x 1.2 m x 1.8 m) of the structure found immediately downstream, this is a tremendous mass to move at once and several masonry boulders have been discovered nearly 3.2 km downstream. To maintain that kind of carrying capacity for so long the flood demonstrated an incredible estimated energy of over 236,000 Watts at the dam (derived from the standard equation ˆ=QpS/w where ˆ = stream power, Q = discharge, p = density, S = slope, and w = stream width) and 420 million Joules (E = Pt, where E = Energy in Joules, P = Power in Watts, and t = time in seconds) for the 1.5 hours it took to drain the reservoir. It is commonly reported the peak discharge at the dam during the flood was a colossal 3,600 m^3/s, and still 850 to 1,250 m^3/s only 3.2 km further downstream,[23] but the knowledge that water was also transporting over 5.7 million kg of masonry boulders those numbers gain new meaning.

Besides estimating how many masonry boulders were displaced, another clue into the flood's behavior is examining where they were deposited. With basic GPS technology and identification methods explained above, spatial patterns of deposition could be mapped and analyzed. Of the 7,900 estimated boulders displaced, only 108 (roughly 2 percent) were located and identified. The disparity could be due to loss of identifying marks, thick vegetation, and the very realistic possibility of being buried beneath the massive quantities of finer sediments moved during the flood, especially since during high water events, it is typically the finer particles that are the last to settle and accumulate. As expected, the majority of the deposition patterns followed basic fluvial principles such as settling on the inner point bars with fewer in the outer cut banks, dropping in clusters where the flood lessened in carrying capacity (e.g., reduced flow competence), and so on, except for The Falls, the only known waterfalls on Cherry Creek (figure 7).

In this section of the study area, approximately 0.8 km downstream from the dam, the canyon walls naturally narrow and the stream gradient increases from 0.0037 m/m to 0.0134 m/m. Consequently, due to the channel contraction and increase in channel gradient, the stream velocity and flow competence increase. In this situation, widely used fluvial methods indicate that little deposition will be located in the channel margins, while here there are several clusters of boulders dropped in the center of the main flow path. What makes this possible is the presence of massive motorhome-sized boulders (roughly 3 m x 4 m x 6 m) funneled by the narrowing canyon during the flood. The original positions of these boulders are unknown, though multiple hypotheses exist. One is that they were buried in the soft bedrock and as the flood eroded the area, they settled on the streambed. Another was that they fell from adjacent cliffs from channel wall scouring and undermining, though the shallow slopes discourage this thought. Yet another possibility is that they dislodged from the steeper, rockier cliffs upstream closer to the dam and the flood rolled them down to where they clustered at the falls and at the canyon mouth (near the USGS Franktown gage). In any case, there is evidence that these colossal boulders were moving during the flood, such as smaller masonry, flimsy pieces of historic sheet metal, and trees lodged *beneath* the boulders.

These massive boulders impeded the flood flow and a number of masonry boulders became wedged and trapped in the ensuing rapids. Historic topographic maps from the USGS and the lack of historic photographs suggest Cherry Creek was a graded stream with no existent knick points or falls directly prior to the 1933 flood. Also supporting this hypothesis is the presence of a gravel bar, a well-established maximum water-level marker and paleostage indicator (Jarrett and England, 2002),[24] level with the tops of the massive boulders but several meters higher than the falls. A number of dressed stones can be found on this particular gravel bar, which would normally raise questions: How were these transported here and how can they be so much higher than The Falls? But in this instance, their existence suggests that they were deposited during the beginning stages of the flood, before the falls were carved, and it wasn't until the flood became channeled as the falls deepened that the upper level became a gravel bar and high-water mark (figure 8). Whether

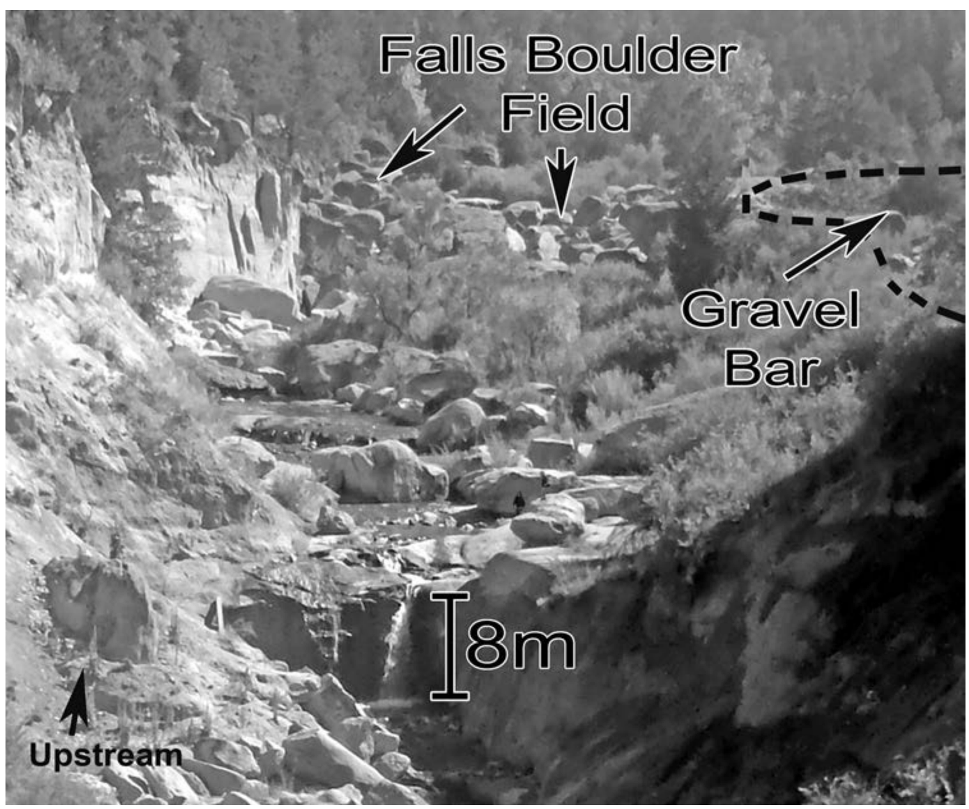

Figure 8: Image of the Falls and congested boulder field looking upstream. Note the two men near the falls for scale. Though not clearly visible from this angle due to vegetation, a large gravel bar extends well past the Falls. *Photo by Kaelin M. Groom.*

Summary of Substantial Rainfall and Flood Events in Cherry Creek Basin				
Flood Name / Location	Date	Precip. Amount (cm)	Precip. Duration (hurs)	Peak Discharge (cfs)
Cherry Creek in Denver	July 14, 1912	Appx. 5.3	2	25,000
Upper Cherry Creek in Parker	June 28, 1922	2.5 – 10	2	17,000
Castlewood Dam Failure	August 2–3, 1933	7.6 – 22.9	9	126,000*
Franktown-Parker	August 5, 1945	5.1 – 12.7	unknown	10.700
Cherry Creek and Plum Creek Divide	June 16, 1965	15.2 – 25.4	3	58,000**
* 126,000 at dam, 34,000 at Franktown, 16,000 in Denver				
** Recorded and containe at Cherry Creek Reservoir, Never reached Denver				
Add smaller floods from Franktown gaging station (esp. 9,170)				

Table 1: Table showing the average discharges of recent floods as monitored by the Unites States Geologic Survey gaging station number 06712000 established in 1936.

through irregular deposition patterns or the hypothetical genesis of the falls as they now are, the spatial analysis of the dam cut blocks begin to elaborate the enormity of this flood and its consequences. But what of the canyon itself?

Sediment Displacement Analyses

Results show that along the 60 m study reach alone almost 10 thousand cubic meters of material was displaced during the 1933 flood event and 1.3 thousand cubic meters from 1933 to 2012 (Table 1). When the averages were applied to the entire 3.2 km downstream canyon it is estimated that nearly 560 thousand cubic meters total was removed in the flood event and another 70 thousand cubic meters post-1933.

The nature and magnitude of the erosion that was attained during this event is both a cause and effect of the local geology. The majority of Castlewood Canyon is composed of the porous yet resilient Castlerock Conglomerate Formation. The dam itself was constructed with cut blocks of the tough conglomerate.[25] However, further downstream the loosely consolidated, and highly erosive, Dawson Arkose Sandstone is exposed. This is where the 1933 flood becomes so instrumental. The only visible outcrop of the Dawson formation runs from the old reservoir and to approximately 2.4 kilometers downstream from the dam. One possible hypothesis for this suggests the upstream canyon has not experienced floods of sufficient magnitude and associated stream power to erode the resilient Castlerock Formation to expose the Arkose. However, the extraordinary nature of the 1933 dam-failure flood was enough to cause downstream disparity. However, there is evidence in historic photographs to suggest small portions of the formation of the Arkose were already exposed in the downstream canyon before 1933, but nowhere near to the extent as today. In any case, preliminary findings suggest the 1933 flood's erosive power stemmed from flood waters exponentially increasing exposure of the weaker Arkose, displacing inordinate amounts of sediment along its downstream path, adding to the sediment supply and overall active load.

Overall Geomorphological Impacts

Although the immediate impacts of the Castlewood Dam failure flood are impressive, the lasting implications are much more profound. Not only were massive quantities of material removed from the canyon, but also cut masonry boulders now litter the canyon adding a new element to the canyon's geomorphology. Stream behavior and deposition patterns have to adjust to the new obstacles, thus altering the path of natural meanders, no matter how small.

Another dramatic change to the canyon is the possible introduction of The Falls. This one point has changed the nature of the stream channel, and fluvial state, as Cherry Creek through Castlewood Canyon is no longer a graded stream. The Falls also add new components to the geomorphology of the canyon with increased turbulence and velocity of the water, more downward erosion below the falls, and

Figure 9: The ruins of the Castlewood Dam, ca. 2012, by Thomas Barrat. *ID 28179822, Dreamstime.com.*

the cluster of up to massive boulders impede nearly all flood debris from continuing downstream. Many of the park's past bridges and various debris washed downstream in recent in floods (most recently on July 2, 2006) can be found lodged in the Fall's upstream boulder field.

Additionally, the deep scouring of the lower canyon effectively cut off the river from the natural flood terraces, sparking an entirely new pattern of erosion and deposition. Comparing pre- and post-1933 USGS quadrilateral 7.5 x 7.5 minute topographic maps also reveals a spatial pattern of erosion. The natural meanders have been widened by an estimated average of 110 m and by as much as 150 m in the areas with higher slopes. As the debris-loaded waters followed the preexisting meanders, the soft Arkose Sandstone channel walls eroded allowing the meanders to widen and deepen. The irony, however, is that these exaggerations are likely to last until the next large flood. The 1933 flood not only scoured the sides of the canyon by as much as 18 m, but the flood also deepened the canyon drastically, in many places as much as 9 m. The overwhelming dam-failure discharge compared to smaller, natural floods had a channeling effect on the canyon and now all subsequent floods must follow the deep resultant channel incision. In the lower canyon below the falls, undercutting the resistant conglomerate suggests the limited impact of relatively small post-1933 floods (the largest known post-1933 flood in the canyon was 260 m^3/s, see Table 1) have on the canyon as a whole. Because the Franktown gage was installed in 1940, we do not have specific data for particular flood events from 1934 to 1939. However, if there had been a substantial flood, it would have been documented by the USGS as a "miscellaneous flood," and no such record exists.

Discussion and Conclusions

The significance of this research is that it offers an introduction to the geomorphology of Castlewood Canyon and lays the groundwork for future exploration. The irregular distribution of the quarried stone from the dam and massive gravel bars at The Falls support a myriad of genetic hypotheses and is now primed for further analysis. Can Castlewood Canyon serve as a case study of waterfalls created through traumatic flood events? The distance these dressed or quarried stone were entrained and moved also reveals potential research. While this study area did not extend past the mouth of the canyon, stone derived from the dam were still being discovered up to that limit and could possibly be found well into the Franktown Valley; their existence and deposition could be mapped. The cross section analysis can also be expanded. More detailed measurements throughout the entire canyon would offer a more accurate assessment of sediment displacement, where this study was only meant to establish a base estimation.

So while the greater details are still yet to be defined the geomorphologic impacts of Denver's forgotten flood have been given new light. In an instant the 1933 Castlewood Dam failure not only altered the shape, composition, and exposed geology in the canyon but also the manner in which the canyon itself changes. The once graded stream is now riddled with turbulence, boulders with no natural reason for existing scatter the exaggerated bends, and Cherry Creek continues its lonely journey through the hollowed deep canyon.

Notes

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