Gunnison River
Hydrologic Analyses Report Addendum

CWCB CONTRACT # COCWCB22A

November 18, 2021

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Introduction

Wood is working with the Colorado Water Conservation Board (CWCB) to develop flood risk data for the Colorado RiskMap project for the Federal Emergency Management Agency (FEMA) that may or may not result in new or updated Flood Insurance Rate Maps (FIRM) and Flood Insurance Study (FIS) reports. This report amends the Gunnison River Hydrologic Analyses Report (Wood, 2020) CWCB Contract # CT PDAA 2017-3860 by adding two new flow change locations.

Scope

New detailed hydrology was previously developed for the Gunnison River within Gunnison County at the location of USGS (United States Geological Survey) Gage 09114500 as part of the original hydrology report (Wood, 2020). The hydrology developed did not cover the entire extent of the scoped Zone AE (detailed study) reach along the Gunnison River. The scope of this addendum is to add additional flow change locations along the Gunnison River to cover the entire Zone AE reach extents.

The hydrology at the additional flow change locations for the Gunnison River was developed using Bulletin 17C flood frequency analysis (FFA) methods using Hydrologic Engineering Center – Statistical Software Package (HEC-SSP) Version 2.2. The Bulletin 17C flows were also projected using peak discharge projection equations presented in the Water Resources Investigations Report (WRIR) 99-4190. A summary of the Zone AE reach is shown in Table 1. The scoped Zone AE reach is displayed in Figure 1.

Table 1 – Detailed Study Summary of Methods

Flooding Source	Reach	Stream Miles	Hydrologic Methodology
Gunnison River	Approximately 950 feet downstream of the County Road 32 bridge to approximately 4,300 feet upstream of the State Highway 135 bridge	8.7	Bulletin 17C Stream Gage Analysis

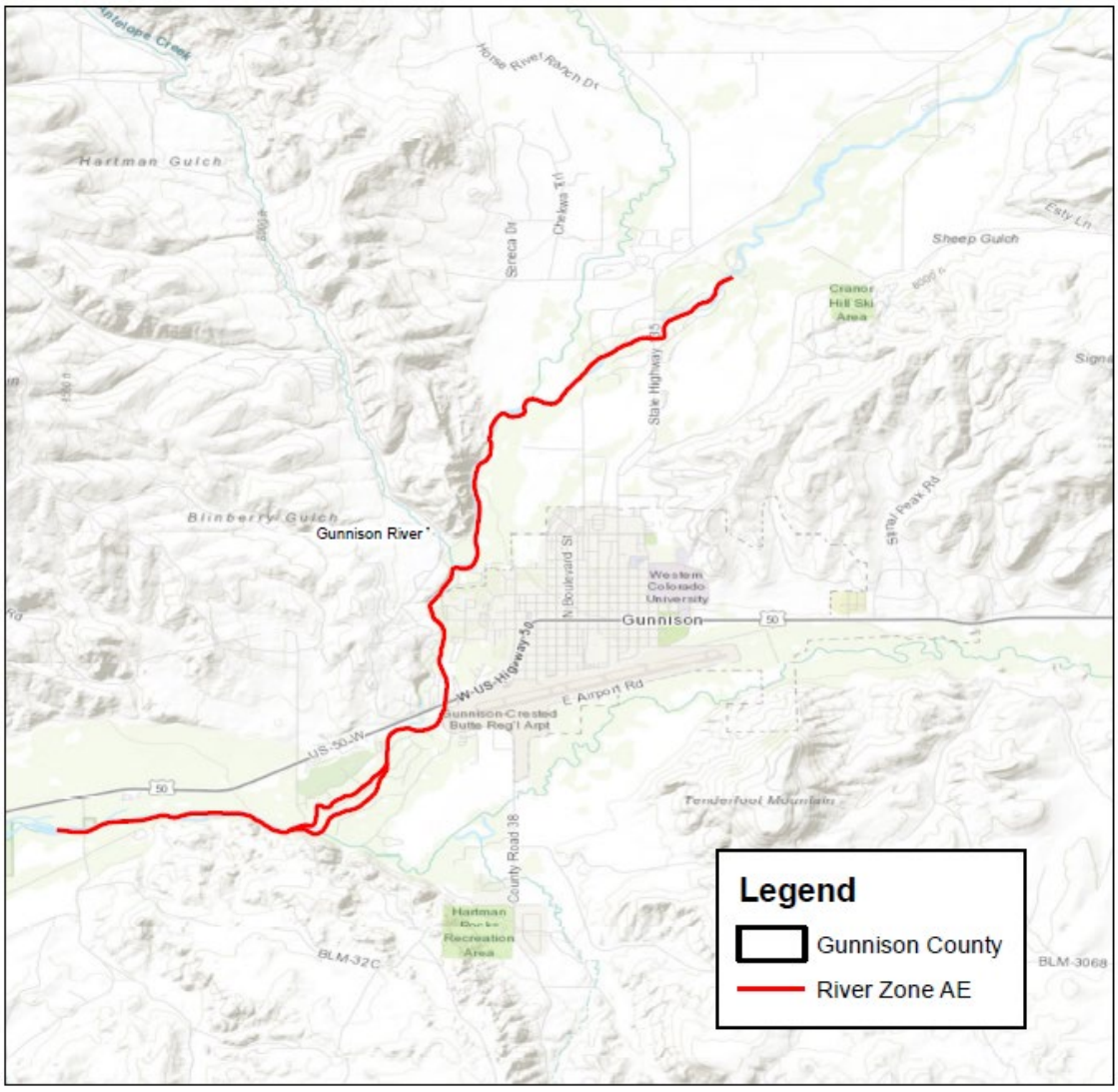

Figure 1 – Zone AE reaches in Gunnison County

Existing Hydrology

See original hydrology report.

Proposed Hydrology

Method Selection

In 2020, a Bulletin 17C flood frequency stream gage analysis was used to determine the hydrology at USGS Gage 09114500 on the Gunnison River (referred to as the Gunnison Gage) as documented in the original hydrology report (Wood, 2020). However, flows were not developed for the entire scoped Zone AE study area which extends below the confluence with Tomichi Creek and upstream up of the US HWY 135 crossing.

The drainage area of the Gunnison River approximately doubles at the confluence with Tomichi Creek and therefore flows from the original Bulletin 17C Analysis could not be projected to the downstream extent of the study reach. The drainage area at US HWY 135 is approximately 80% of the drainage area at the Gunnison Gage and therefore developed flows could be projected. This addendum documents the new hydrologic analysis for the Gunnison River downstream of the confluence with Tomichi Creek as well as projects flows from the original gage analysis to the upstream extent of the study.

To develop flows for the Gunnison River downstream of the confluence with Tomichi Creek available data was assessed. Historically, the USGS maintained a gage on the Gunnison River at Iola, Colorado (USGS Gage 09120500) which is approximately 8.8 miles downstream of the confluence with Tomichi Creek. This gage has 18 years of recorded peak flow data, and a preliminary Bulletin 17C flood frequency stream gage analysis was developed for the site. Due to the limited gage record and the lack of major historical floods during the recorded period, this analysis returned flows less than those estimated at the Gunnison Gage (USGS Gage 09114500). Therefore, it was determined that this was not an acceptable method for developing study hydrology. There are no other gages on the Gunnison River downstream of the confluence with Tomichi Creek that are above the impact of the Blue Mesa Reservoir and other major tributaries.

The USGS does maintain an active gage on Tomichi Creek (USGS gage 9119000 Tomichi Creek at Gunnison) approximately 2.3 miles upstream of the confluence with the Gunnison River. Adding the drainage area of this gage and of the Gunnison Gage yields a combined drainage area equal to approximately 98% of the total drainage area of the Gunnison River below the confluence with Tomichi Creek (See Table 2). Therefore, a combined gage record from these two gages should produce a reasonable estimation of historic flows on the Gunnison River below the confluence with Tomichi Creek. A combined gage record was developed and used to create a Bulletin 17C flood frequency analysis as described in the *Bulletin 17C Stream Gage Analysis* Section of this report.

Table 2 – Gage Areas

USGS Gage ID	Flood Source	Drainage Area (Sq Mi.)
09114500	Gunnison River	1,011
09119000	Tomichi Creek	1,061
Sum of Drainage Areas		**2,072**
Drainage Area at Confluence		**2,120**

At the upstream extent of the scoped reach, the drainage area is approximately 80% of the drainage area at the Gunnison Gage. In hydraulic modeling, it is desirable to have a flow change location for approximately every 10% increase in the 1% annual chance event flow based on FEMA guidance, and therefore it was determined that an additional flow change location was necessary. WRIR 99-4190 provides peak discharge projection equations and states that they are considered reliable for drainage area ratios between 0.5 and

1.5. Therefore, as part of this hydrology addendum, an additional flow change location was projected along the Gunnison River. This is discussed in more detail under the *Streamflow Projections* Section of this report.

The following sections describe the Bulletin 17C Analysis and the flow projection in greater detail.

Bulletin 17C Stream Gage Analysis

The combined gage record for Tomichi Creek and the Gunnison River was evaluated in HEC-SSP Version 2.2 using the Log-Pearson Type III (LPIII) and Expected Moments Algorithm (EMA) outlined in Bulletin 17C. The annual peak flow data for both gages was obtained from the USGS website and manually combined in Microsoft Excel. Skew is a measure of the asymmetry of the probability distribution of a real-valued random variable about its mean. The station skew option is based solely on computing a skew from the data points contained in the dataset. Station skew was chosen due to the significant record length of the combined record.

The two gages used to develop the combined gage record and the flows for the Gunnison River below the confluence with Tomichi Creek are:

- USGS Gage//DWR Gage – Gunnison River near Gunnison (09114500//GUNGUNCO)
- USGS Gage// DWR Gage – Tomichi Creek near Gunnison (0911900//TOMGUNCO)

USGS Qualification Codes

Qualification codes were available for the Gunnison River and Tomichi Creek near Gunnison. Table 3 shows the codes encountered within the data. The codes within this table are only for the data used in this analysis.

Table 3 – USGS Qualification Codes and Approach

Code #	Description	Approach
Gunnison River Peak Flow Data		
1	Discharge is a Maximum Daily Average	No change in approach.
2	Discharge is an Estimate	No change in approach.
5	Discharge Affected to Unknown Degree by Regulation or Diversion	No change in approach.
Gunnison River Daily Discharge Data		
e	Value has been estimated	No change in approach.
Tomichi Creek Peak Flow Data		
1	Discharge is a Maximum Daily Average	No change in approach.
2	Discharge is an Estimate	No change in approach.
2	Gage Height not the maximum for the year	No change in approach.
Tomichi Creek Daily Discharge Data		
	No codes listed for data used	

09114500 – Gunnison River Near Gunnison, CO (GUNGUNCO)

A description of this gage and the data is provided in the original hydrologic report. One additional year of data (2020) was published since the original report and was included in this analysis. Additionally, daily discharge data was also used to create the combined gage record. There were two instances of gage code e (Value has been estimated) within the daily discharge data used. No change in approach was made for these two data points.

09119000 – Tomichi Creek at Gunnison, CO (TOMGUNCO)

Operator: USGS
Previous Operator: None
Location: At approximately the intersection of County Road 38 and E Airport Rd in Gunnison, CO. (38° 31' 16" N, 106° 56' 27.45" W)
Drainage Area: 1,061 square miles
Elevation: 7628.585 feet, NGVD29
Annual Peak Stream Flow Records: 83, between June 1938 and June 2020
Still Active: Yes

General Notes: Major flooding along Tomichi Creek has occurred as recently as 2004. The Gunnison County FIS reports states that in July 2004 a section of County Rd 72 was damaged by flooding on Tomichi Creek. Flooding in August of 1999 was estimated to exceed the 0.2% annual chance flood event.

Gage Codes: The records from 1945 to 2020 were the only years used in the combined gage analysis since these are the only years where records overlap with the Gunnison Gage. Within these dates for peak flow data, there were USGS qualification codes of 1 (Discharge is a maximum Daily Average) and 2 (Discharge is an estimate). These flows were examined to determine if they were in the top 5% of records and were found not to be, so therefore, were treated as annual peaks just like the other data. The one gage height qualification code (code 2 – Gage height not the maximum for the year) was recorded in 2018. The peak flow in 2018 actually took place at the end of 2017. This is possible since the water year starts in the fall. For the daily discharge data, all records between 1945 and 2020 have a USGS qualification code of A (Approved for publication – Processing and review completed). No modification to the record was made as a result of this code.

Data Gaps: No gaps exist in this data set.

Gunnison River and Tomichi Creek Combined Record Analysis

Record Combination: As described in the *Method Selection* section, there was not sufficient gage data on the Gunnison River below the confluence with Tomichi Creek to accurately estimate flows at this location and therefore a combined gage record was created. The two gage records overlap from 1945 until 2020 providing a sufficiently long record. Simply adding the peak flows from these two gages would be overly conservative since the two watersheds are large and unlikely to peak at the same time, as evidenced by the annual peak flows for the two streams typically occurring on different days each year. Therefore, to create the combined record, the peak flow data from one stream was added to the daily average flow data from the other stream and the maximum of these two events was selected as the annual peak flow.

The average daily flows used for this analysis were also downloaded from the USGS website. Since these flows are daily average flows and not instantaneous peak flows, the Gunnison River flows were increased by 8% and the Tomichi Creek flows were increased by 17% to reflect peak flow conditions. These adjustments were determined by taking the average percent difference between the instantaneous peak flow and daily average flow on that day for each gage.

A spreadsheet including the data used and the calculations and adjustments made is included in the supplemental data submitted with this report.

General Notes: The combined gage data had to be manually entered into HEC-SSP. Additionally, two large events recorded at the Gunnison Gage but outside of the period of overlapping records were also included in the 17C Analysis. These flows were increased by 30% which was an estimate what the peak flows would have been below the confluence with Tomichi Creek based on preliminary results. The recorded flow from the Gunnison Gage was used as the lower limit and a 30% upper bound was applied. The Tomichi Creek gage records did not include any major events outside of the overlapping record. A perception threshold of 9,000cfs was set for all other years from 1911 until 1944 since a more major flood event on the Gunnison River would have been reflected at the Gunnison Gage. The areas for the gages can be seen in Table 2.

LOT: The Multiple Grubbs-Beck Test computed a critical value of 2,000cfs and resulted in seven records being censored from the results. Due to the computed curve being below some of the highest records in the data set, manual adjustment of the LOT was attempted; however, this modification did not result in a significant change to the computed curve and therefore the original computed value was used.

The resulting flood frequency curve for the Gunnison River below the confluence with Tomichi Creek is shown in Figure 2. The final computed peak flows are shown in Table 5.

Streamflow Projection

As mentioned in *Method Selection,* it is desirable to have flow change locations for approximately every 10% increase in the 1% annual chance event. To determine where additional flow change locations might be necessary, drainage areas along the Gunnison River were calculated using USGS StreamStats (USGS, 2021) at the upstream and downstream study extents as well as at major confluences, as shown in Table 4. The peak discharge projection equation from Water Resources Investigations Report 99-4190, presented below, was then used to estimate the 1% annual chance flood at each of these locations. The percent change between the peak flow below Antelope Creek and the peak flow below Ohio Creek was only 3% due to the relatively small change in drainage area. Therefore, the flows estimated at the Ohio Creek location are not included in the final flow values presented in Table 5. An excel spreadsheet showing these calculations is included in the supplemental data submitted with this report.

Table 4 – Drainage Areas along Gunnison River within Project Extents

Location	Drainage Area delineated using USGS StreamStats (Sq Mi.)
HWY 135	810
Below Ohio Creek	970
Below Antelope Creek (Gunnison Gage)	1,010
Above Tomichi Creek	1,010
Below Tomichi Creek	2,120
Downstream Extent	2,120

Equation 1

$$Q_{T(u)} = Q_{T(g)}(A_u/A_g)^x$$

Where $Q_{T(u)}$ is the peak discharge, in cubic feet per second, at the ungaged site for T-year recurrence interval; $Q_{T(g)}$ is the weighted peak discharge, in cubic feet per second, at the gaged site for T-year recurrence interval; A_u is the drainage area, in square miles, at the ungaged site; A_g is the drainage area, in square miles, at the gaged site; and x is the average exponent for drainage area.

An exponent of 0.69 was selected because the project location falls within the Mountain Region.

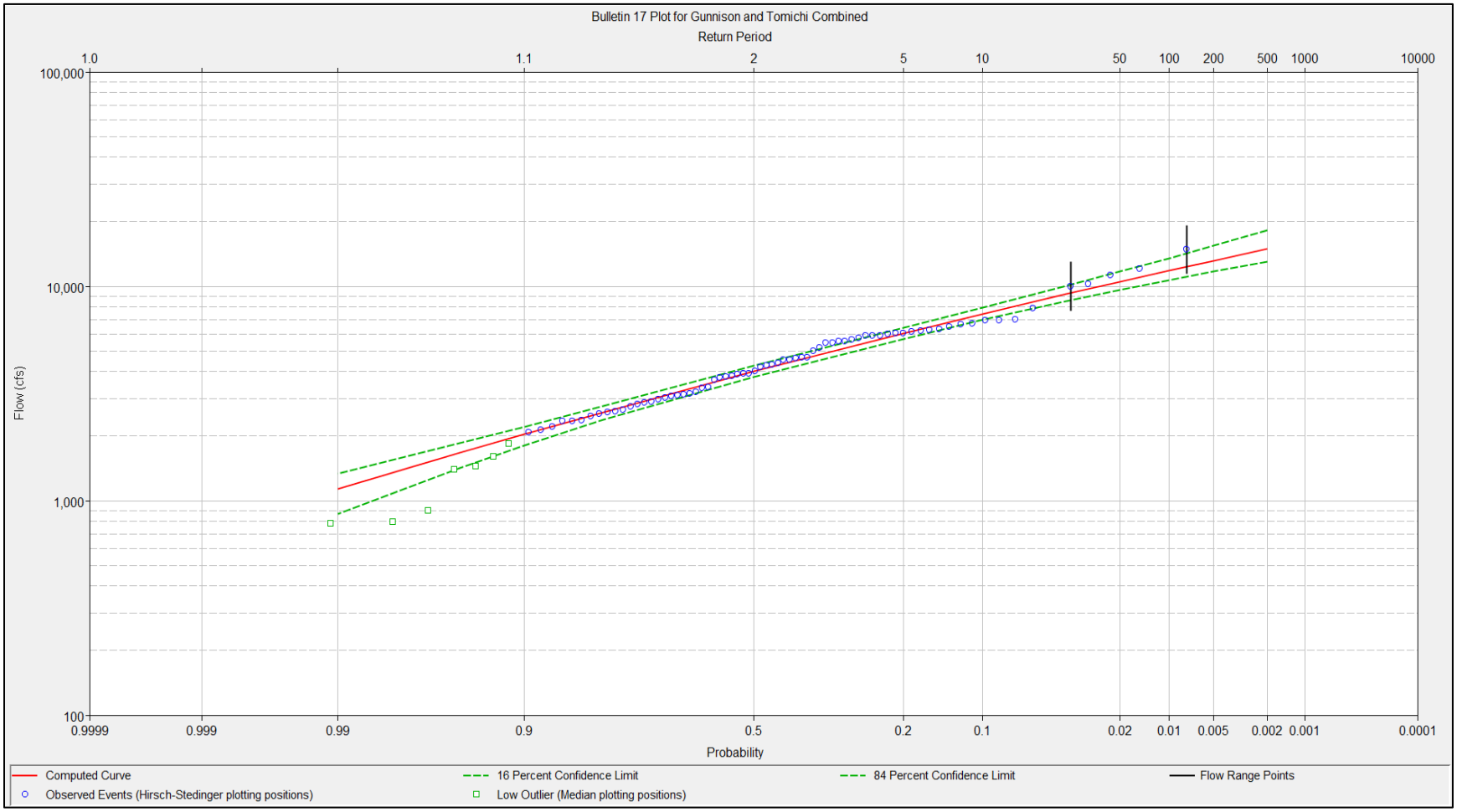

Figure 2 – Bulletin 17C Frequency Curve for Combined Gage Record

Table 5 – Final Flows for the Gunnison River in Gunnison County, Colorado

Gage/Location		Drainage Area [1]	Projection Ratio	Peak Discharge (cfs)					
Number	Location	(mi^2)		10%	4%	2%	1%	1% Plus	0.20%
NA	At Highway 135	810	0.80	5,290	6,310	7,010	7,680	8,430	9,100
09114500// GUNGUNCO	Below Confluence with Antelope Creek	1,011	NA	6,170	7,350	8,170	8,950	9,820	10,600
Combined Record	Below Confluence with Tomichi Creek	2,120	NA	7,420	9,190	10,510	11,830	13,530	14,920

Values presented in black are from the original 2020 hydrologic analysis. Values shown in red were determined by this addendum.

Summary

As a result of the detailed analyses performed, additional peak discharges have been developed along the Gunnison River for the 10%, 4%, 2%, 1%, 1%+, and 0.2% annual chance storm events. The flows resulting from these analyses will be used for the detailed hydraulic analysis and floodplain mapping along the scoped portion of the Gunnison River within Gunnison County. Additional information about the analyses preformed and the HEC-SSP model developed have been included with this submittal.

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