COLORADO
Parks and Wildlife
Department of Natural Resources

Water Resources Section – Aquatic, Terrestrial, and Natural Resources Branch

December 22, 2023

Mr. Rob Viehl, Section Chief
Colorado Water Conservation Board
Stream and Lake Protection Section
1313 Sherman Street, 7th Floor
Denver, CO 80203

Subject: Instream Flow Recommendations for Williams Gulch in Water Division 1, Larimer County to be presented at the January 2024 CWCB Meeting

Dear Mr. Viehl:

The information contained within and referred to in this letter forms the scientific and biological basis for an instream flow (ISF) recommendation on Williams Gulch in Water Division 1. Field investigations relating to this ISF recommendation were conducted by Colorado Parks and Wildlife (CPW) and Colorado Water Conservation Board (CWCB) staff in 2023. Williams Gulch is a high-elevation stream that CPW reclaimed to support native greenback cutthroat trout in 2021. This ISF recommendation was presented to interested parties at the ISF Workshop in January 2023. CPW and CWCB staff also conducted outreach to the Larimer County Commissioners in December 2023. It is CPW staff's opinion that the information contained in this letter is sufficient for the CWCB's staff to recommend an ISF appropriation to the Board on Williams Gulch as it specifically addresses the findings required in Rule 5(i) of the Instream Flow Program Rules.

CPW participates in the ISF Program and develops ISF recommendations for the Board's consideration in an effort to address CPW's legislative directives "… that the wildlife and their environment are to be protected, preserved, enhanced, and managed for the use, benefit, and enjoyment of the people of this state and its visitors … and that, to carry out such program and policy, there shall be a continuous operation of planning, acquisition, and development of wildlife habitats and facilities for wildlife-related opportunities" [§33-1-101 (1) C.R.S.], and "… that the natural, scenic, scientific, and outdoor recreation areas … be protected, preserved, enhanced and managed for the use, benefit, and enjoyment of the people of this state and (its) visitors … and that, to carry out such program and policy, there shall be a continuous operation of acquisition, development, and management of … lands, waters, and facilities." [§33-10-101 (1) C.R.S.].

In addition to these broad statutory guidelines, CPW's strategic planning document (CPW Strategic Plan, 2015) explains the agency's current goals to, "[c]onserve wildlife and habitat to ensure healthy sustainable populations and ecosystems" in order to, "protect and enhance water resources for fish and wildlife populations," by pursuing, "partnerships and agreements to enhance instream flows, protect reservoir levels, and influence water management activities," and to, "[a]dvocate for water quality and quantities to conserve aquatic resources." In addition to the CPW strategic plan, the agency's fish and wildlife conservation activities are also informed by the State Wildlife Action Plan

(2002, Revised 2015). The aforementioned documents direct CPW to advocate for the preservation of the state's fish and wildlife resources and natural environment, and therefore link CPW's mission to the goals and priorities of CWCB's Instream Flow and Natural Lake Level Program.

Recommended Segments

CPW is proposing an ISF recommendation on Williams Gulch from the headwaters, located at UTM 13S 431929.17 4509289.75, to the confluence with the Cache la Poudre River (Poudre River), located at UTM 13S 436481.69 4506563.58. The reach is approximately 4.6 miles in length. The upper portions of the proposed reach are on public lands managed under the Roosevelt National Forest. A short section of Williams Gulch, approximately 0.5 miles above the confluence with the Poudre River, is on CPW's Bliss Creek State Wildlife Area.

Greenback Cutthroat Trout Conservation Goals

The greenback cutthroat trout was designated Colorado's state fish in 1994. This subspecies of cutthroat trout is listed as a threatened species by both the state and federal government. Following the listing of the greenback cutthroat trout under the authorities of the Endangered Species Act of 1973, state and federal fish and wildlife managers have engaged in efforts to recovery the species and establish new populations of this subspecies around the state of Colorado. The greenback cutthroat trout recovery plan's overall goal is as follows:

> "Recovery needs for the Greenback Cuththroat Trout include the establishment of conservation populations through stocking efforts into streams and lakes with suitable habitat throughout the South Platte River drainage, and possibly within adjacent drainages east of the Continental Divide. Populations need to be sufficiently robust (i.e. resilient and redundant) to withstand stochastic, catastrophic, and anthropogenic influences such that they can persist into the future. Meeting these goals will require that threats be sufficiently understood and abated, and range-wide monitoring will be required." (Recovery Outline for the Greenback Cutthroat Trout, 2019)

Establishing new conservation populations of greenback cutthroat trout and protecting the habitat where these populations reside are both critical steps to the successful recovery of the species. CPW believes that ISF protection on Williams Gulch is an imporant step in the overall conservation of greenback cutthroat trout.

Natural Environment and Biological Summary

Williams Gulch is a high-elevation headwaters creek located east of the Rawah Wilderness. The creek flows southeasterly and directly into the Poudre River near Kinikinik off Cameron Pass. The contributing drainage basin is approximately 3.9 square miles. The basin is forested and mountainous with a mean elevation of 9,800 feet. The stream's hydrology is snowmelt-driven into the late summer, and the basin receives approximately 24 inches of precipitation a year.

Williams Gulch is a high-gradient headwaters steam. At the Poudre River valley floor, the channel begins anastamosing and transitions to a wetland, beaver dam complex. It then merges into a main

channel and crosses under Highway 14 to its confluence with the Poudre River. Substrate observed in this reach ranges from sand to large cobbles. Williams Gulch supports ideal cutthroat trout habitat including the following: large pools, amble large woody debris, long runs, undercut banks, gravel spawning beds, and aquatic macrophyte and diatom communities throughout the channel.

For decades, Williams Gulch supported a self-sustaining population of Colorado River cutthroat trout. This suitable cutthroat habitat made it a prime candidate stream for greenback cutthroat trout recovery. In September 2021, CPW biologists lead a successful chemical reclamation project to remove the Colorado River cutthroat trout from Williams Gulch with the end goal of establishing native greenback cutthroat trout. Following the reclamation, fish electroshocking efforts confirmed all non-native cutthroat had been removed from the creek. In September 2022, CPW biologists and volunteers stocked young-of-the-year greenback cutthroat trout in the stream.

Williams Gulch also supports an abundant macroinvertebrate community which includes multiple types of cased caddisfly, multiple types of stoneflies, mayflies, and diptera. Additionally, Colorado Natural Heritage Program notes a rare, globally imperiled, plant association within the watershed. The association is Wyoming Big Sagebrush and Rocky Mountain Wildrye Shrubland which occurs on steep south-facing slopes in the Poudre River watershed. In 2020, the lower part of the watershed burned in the Cameron Peak wildfire. Fire impacts are evident and have resulted in a major reconfiguration of the channel. The wet meadow complex supported by Williams Gulch remains intact and healthy despite the recent fire activity and the burned mature pine stands in lower portions of the watershed.

R2Cross Background

Initial biological flow recommendations were developed using the R2Cross methodology (Espegren, 1996[1]). R2Cross uses field data collected in a riffle habitat type. Riffles are often the limiting habitat features in streams during low flow events, so maintaining specific hydraulic conditions across riffle habitat types will also maintain aquatic habitat in pools and runs for most life stages of fish and macroinvertebrates (Nehring, 1979[2]). The R2Cross model uses field data, including a survey of cross-sectional channel geometry, a longitudinal slope of the water surface, and a flow measurement, as inputs to a single transect hydraulic model. R2Cross uses the Ferguson Variable-Power Equation (Ferguson, 2007[3]) to model a stage-discharge relationship and to compute corresponding hydraulic parameters of average depth, average velocity, and percent wetted perimeter over modeled stages. Maintaining these three hydraulic parameters at specified levels should ensure conditions that allow for the movement of fish longintudinally across riffles and provide adequate depths, velocities, and oxygenation for the production of macroinvertebrates and development of trout eggs.

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[1]Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

[2]Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

[3] Ferguson, R.I., 2007. Flow resistance equations for gravel- and boulder-bed streams. Water Resources Research 43. https://doi.org/10.1029/2006WR005422

Baseflow recommendations are typically developed based on the flows that meet two of the three hydraulic criteria, and summer flow recommendations are based on hydraulic criteria that meet all three of the three hydraulic criteria (as described in Nehring 1979 and Espergren 1996).

In 2023, CPW and CWCB staff collected two cross-section data sets on the lower portion of Williams Gulch on Bliss SWA. The results of the R2Cross analysis are summarized below.

	Bankfull Top Width	Date Measured	Flow Measured	Flow Meeting Two Criteria	Flow Meeting Three Criteria
1	8.54 ft	7/11/2023	2.43 cfs	1.00 cfs	2.3 cfs
2	11.58 ft	7/11/2023	2.43 cfs	1.39 cfs	1.78 cfs
Recommended Flow Rates:				**1.2 cfs**	**2.0 cfs**

The initial biological flow recommendation during the baseflow period is 1.2 cfs. This rate is protective during the overwintering period as it maintains adequate wetted perimeter, average depth of 0.2 feet in cross-section one, and average velocity of 1 foot per second (fps) in cross-section two. The initial biological flow recommendation in the summer is 2.0 cfs, which will maintain these hydraulic parameters in both surveyed critical riffle transects.

In order to make a preliminary determination whether water is available for the R2Cross-based flow recommendations and to determine the appropriate seasonal transition dates, CPW examined basic hydrologic data and water rights information for Williams Gulch. Williams Gulch does not have any gage data, and because it is high-elevation and undeveloped, CWCB staff relied upon regression equations for monthly flow estimates to determine the seasonality of the flow recommendations. CPW is not aware of any active water rights within the reach.

<u>Water Availability-Refined Flow Recommendation</u>

CPW's analysis indicates that the following flows are needed to protect the natural environment to a reasonable degree. Based on the hydrology from CSUFlow18 (Eurich et al., 2021[4]), there appears to be water availablity limitations during the fall and winter periods. Therefore, CPW's adjusted flow recommendation are the following:

- Spring and Summer Flow Recommendation (April 1 through July 31): **2.0 cfs**
    - Maintains adequate depth, velocity, and wetted perimeter during the spring and summer when fish have more metabolic activity during their periods of increased activity. This higher flow rate will support beneficial feeding and spawning conditions as greenback cutthroat trout mature and grow.

[4] Eurich, A., Kampf, S.K., Hammond, J.C., Ross, M., Willi, K., Vorster, A.G. and Pulver, B., 2021, Predicting mean annual and mean monthly streamflow in Colorado ungauged basins, River Research and Applications, 37(4), 569-578.

- Late Summer Flow Recommendation (August 1 through August 31): **1.1 cfs**
    - Maintains adequate wetted perimeter and sufficient depth and velocity while water temperatures may be high in the late summer. Although this flow rate is reduced slightly due to water availability constraints, it should maintain resting habitat for greenback cutthroat trout.
- Fall Flow Recommendation (September 1 through October 31): **0.7 cfs**
    - This flow rate has been reduced due to water availability constraints but will maintain adequate wetted perimeter and depth in runs and pools to support greenback cutthroat trout. This flow rate will also allow fish to move to more stable habitat for the overwintering period.
- Baseflow Recommendation (November 1 through March 31): **0.4 cfs**
    - This flow rate has been reduced due to water availability constraints,but will maintain adequate available habitat in runs and pools to support fish during the overwintering period.

The purpose of this letter is to formally transmit this ISF recommendation to CWCB for the Board's consideration. CPW believes there is a flow-dependent natural environment in Williams Gulch that can be preserved to a reasonable degree with an ISF water right in the recommended rates. Please refer to attachments which include: R2Cross field forms, R2Cross output, flow measurements, fish stocking photographs, and photographs at each cross-section location.

CPW personnel will be available at the January 2024 CWCB meeting to answer any questions that the Board might have regarding these flow recommendations. We appreciate your consideration.

Sincerely,

Katie Birch Digitally signed by Katie Birch Date: 2024.01.10 11:19:48 -07'00'

Katie Birch
CPW Instream Flow Program Coordinator
Attachments (as stated)

FIELD DATA FOR INSTREAM FLOW DETERMINATIONS

COLORADO WATER CONSERVATION BOARD

COLORADO DIVISION OF WILDLIFE

LOCATION INFORMATION

STREAM NAME: Williams Gulch					CROSS-SECTION NO.: 1-23
CROSS-SECTION LOCATION: @Bliss SWA 13T 436363 4506610					
DATE: 7/11/23	OBSERVERS: K Birch M. Sidell				
LEGAL DESCRIPTION	¼ SECTION:	SECTION:	TOWNSHIP: N/S	RANGE: E/W	PM:
COUNTY: Larimer	WATERSHED: Poudre		WATER DIVISION:		DOW WATER CODE:
MAP(S):	USGS:				
	USFS:				

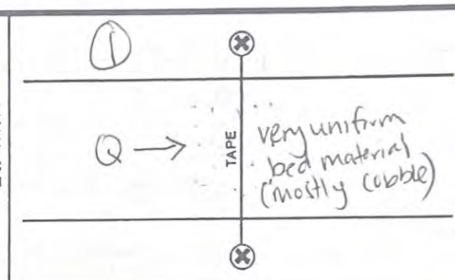
SUPPLEMENTAL DATA

SAG TAPE SECTION SAME AS DISCHARGE SECTION: YES/NO (NO circled)	METER TYPE: Flowtracker 2 (measured 50' d/s in glide)			
METER NUMBER:	DATE RATED:	CALIB/SPIN: ____ sec	TAPE WEIGHT: ____ lbs/foot	TAPE TENSION: ____ lbs
CHANNEL BED MATERIAL SIZE RANGE: Small cobble, some large sand & lg cobble		PHOTOGRAPHS TAKEN: YES/NO (YES circled)	NUMBER OF PHOTOGRAPHS: 3 by KB	

CHANNEL PROFILE DATA

STATION	DISTANCE FROM TAPE (ft)	ROD READING (ft)
⊗ Tape @ Stake LB	0.0	~
⊗ Tape @ Stake RB	0.0	~
① WS @ Tape LB/RB	0.0	6.15 / 6.16
② WS Upstream	22.8	5.79
③ WS Downstream		6.40
SLOPE	~2%	

SKETCH



LEGEND: Stake ⊗ Station ① Photo ◇→ Direction of Flow

6.15

AQUATIC SAMPLING SUMMARY

STREAM ELECTROFISHED: YES/NO	DISTANCE ELECTROFISHED: ____ ft	FISH CAUGHT: YES/NO	WATER CHEMISTRY SAMPLED: YES/NO

LENGTH - FREQUENCY DISTRIBUTION BY ONE-INCH SIZE GROUPS (1.0-1.9, 2.0-2.9, ETC.)

SPECIES (FILL IN)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	>15	TOTAL
macros abundant																	

AQUATIC INSECTS IN STREAM SECTION BY COMMON OR SCIENTIFIC ORDER NAME:

COMMENTS

Great fish habitat. undercut banks. large deep pools. LWD (new from Cameron fire) in channel. wet meadow/Beaver ponds (lg) upstream. Aquatic macrophytes abundant throughout channel. pine (burned), some ~~pine~~ fines/ash in stream but riffle/spawning & algae) habitat ~~~~ good willows, abundant wetland plants/sedges ~ fire buffering but pines are all burned (were healthy)

FORM #ISF FD 1-85

DISCHARGE/CROSS SECTION NOTES

STREAM NAME: Williams Gulch	CROSS-SECTION NO: 1	DATE: 7/11/23	SHEET 2 OF 3
BEGINNING OF MEASUREMENT	EDGE OF WATER LOOKING DOWNSTREAM: (0.0 AT STAKE) LEFT / RIGHT	Gage Reading: N/A ft	TIME: 11:36 AM

Features: Stake (S) Grassline (G) Waterline (W) Rock (R)	Distance From Initial Point (ft)	Width (ft)	Total Vertical Depth From Tape/Inst (ft)	Water Depth (ft)	Depth of Observation (ft)	Revolutions	Time (sec)	Velocity (ft/sec) At Point	Velocity (ft/sec) Mean in Vertical	Area (ft^2)	Discharge (cfs)
S	0		5.6								
BF	0.75		5.84								
LWS	1.1		6.15	0							
	1.15		6.43	0.32							
	1.5		6.51	0.39							
	1.9		6.49	0.31							
	2.3		6.40	0.23							
	2.7		6.48	0.31							
	3.1		6.46	0.32							
	3.5		6.49	0.32							
	3.9		6.44	0.30							
	4.3		6.37	0.20							
	4.7		6.50	0.31							
	5.1		6.46	0.25							
	5.5		6.43	0.24							
	5.9		6.36	0.25							
	6.3		6.37	0.30	#2 Thalweg, Swift						
	6.7		6.40	0.25							
	7.1		6.39	0.25							
	7.5		6.45	0.4							
	7.9		6.49	0.4							
	8.3		6.46	0.3							
	8.7		6.37	0.25							
RWS	9.1		6.35	0.2							
	9.2		6.10	0	0						
BF	~~9.0~~ 9.3		5.85								
	9.7		5.75								
	10.3		5.25								
S	10.2		5.06								
TOTALS:											

End of Measurement	Time:	Gage Reading: ____ ft	CALCULATIONS PERFORMED BY:	CALCULATIONS CHECKED BY:

COLORADO WATER CONSERVATION BOARD

FIELD DATA FOR INSTREAM FLOW DETERMINATIONS

LOCATION INFORMATION

STREAM NAME: Williams Gulch					CROSS-SECTION NO.: 2-23
CROSS-SECTION LOCATION: @Bliss SWA					
13T 436347 4506448					
DATE: 7/11/23	OBSERVERS: Birch Sidell				
LEGAL DESCRIPTION	¼ SECTION:	SECTION:	TOWNSHIP: N/S	RANGE: E/W	PM:
COUNTY: Larimer	WATERSHED: Poudre	WATER DIVISION:		DOW WATER CODE:	
MAP(S): USGS:					
USFS:					

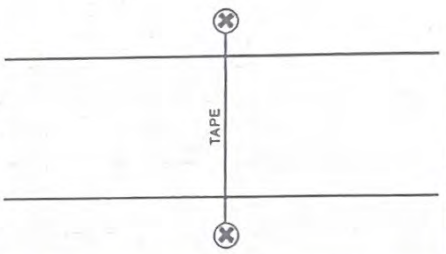
SUPPLEMENTAL DATA

SAG TAPE SECTION SAME AS DISCHARGE SECTION: YES (NO)	METER TYPE: Measured d/s below XS. 1 w/ FT2 by M.S.			
METER NUMBER:	DATE RATED:	CALIB/SPIN: ____ sec	TAPE WEIGHT: ____ lbs/foot	TAPE TENSION: ____ lbs
CHANNEL BED MATERIAL SIZE RANGE:	PHOTOGRAPHS TAKEN: YES/NO	NUMBER OF PHOTOGRAPHS:		

CHANNEL PROFILE DATA

STATION	DISTANCE FROM TAPE (ft)	ROD READING (ft)
⊗ Tape @ Stake LB	0.0	X
⊗ Tape @ Stake RB	0.0	X
① WS @ Tape LB/RB	0.0	5.71 / 5.73
② WS Upstream	14.3'	5.73
③ WS Downstream		5.91
SLOPE	~1%	

SKETCH



LEGEND:
Stake ⊗
Station ①
Photo ①→
Direction of Flow ← →

5.73

AQUATIC SAMPLING SUMMARY

STREAM ELECTROFISHED: YES/NO	DISTANCE ELECTROFISHED: ____ft	FISH CAUGHT: YES/NO	WATER CHEMISTRY SAMPLED: YES/NO

LENGTH - FREQUENCY DISTRIBUTION BY ONE-INCH SIZE GROUPS (1.0-1.9, 2.0-2.9, ETC.)

SPECIES (FILL IN)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	>15	TOTAL
caddis (2) w/ cases																	
stonefly (2)																	
mayfly																	
diptera																	

AQUATIC INSECTS IN STREAM SECTION BY COMMON OR SCIENTIFIC ORDER NAME:

COMMENTS

Q = 2.4 cfs

FORM #ISF FD 1-85

DISCHARGE/CROSS SECTION NOTES

STREAM NAME: Williams	CROSS-SECTION NO.: 2	DATE: 7/11/23	SHEET 2 OF 2
BEGINNING OF MEASUREMENT	EDGE OF WATER LOOKING DOWNSTREAM: (0.0 AT STAKE) (LEFT) / RIGHT	Gage Reading: _____ ft	TIME: 151

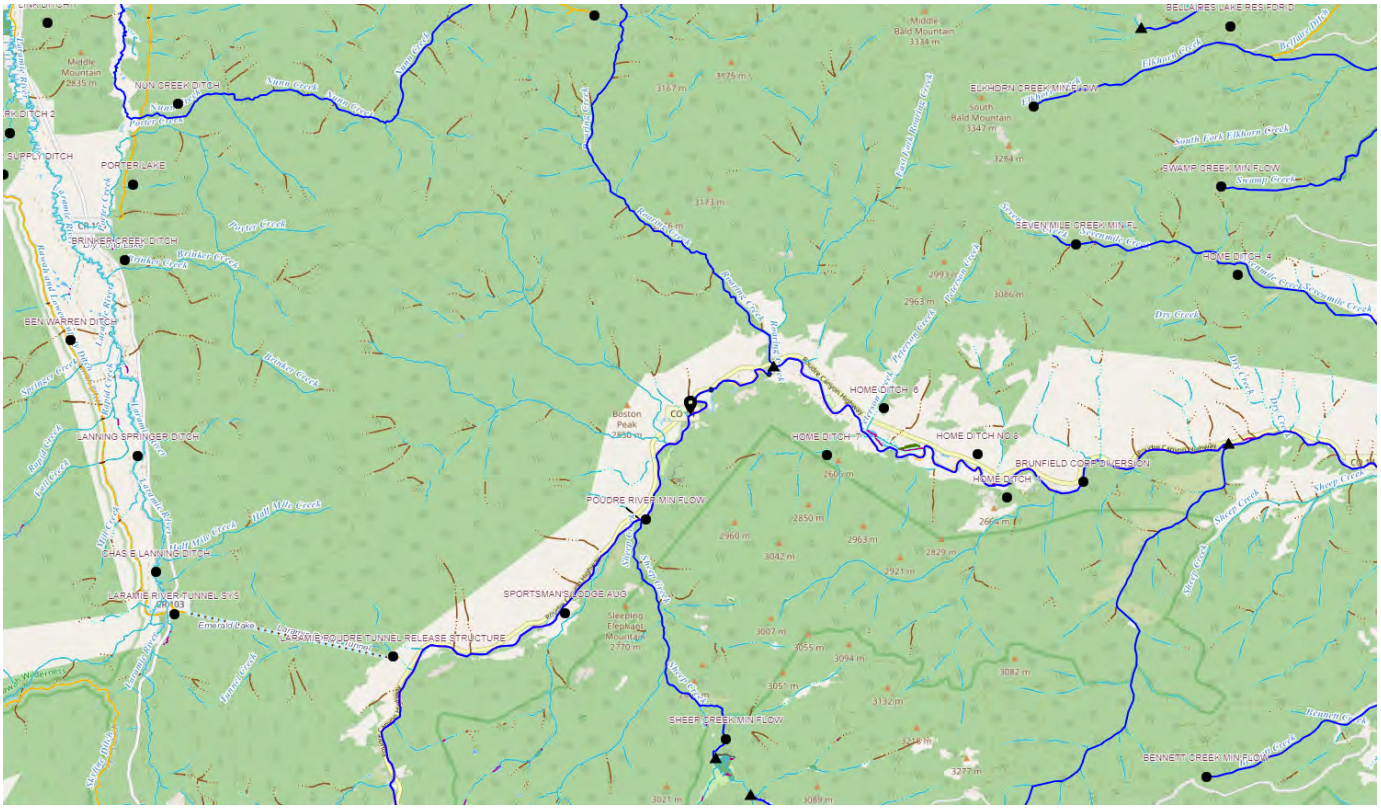
Features: Stake (S) Grassline (G) Waterline (W) Rock (R)	Distance From Initial Point (ft)	Width (ft)	Total Vertical Depth From Tape/Inst (ft)	Water Depth (ft)	Depth of Observation (ft)	Revolutions	Time (sec)	Velocity (ft/sec) At Point	Velocity (ft/sec) Mean in Vertical	Area (ft^2)	Discharge (cfs)
S	0		4.36								
	.8		4.61								
BF	1.5		4.95								
LWS	2.3		5.74	0							
	2.7		5.96	0.28							
	3.1		5.98	0.30							
	3.5		5.93	0.22							
	3.9		5.97	0.28							
	4.3		5.91	0.25							
	4.7		5.94	0.25							
	5.1		5.82	0.2							
	5.5		5.87	0.2							
	5.9		5.91	0.25							
	6.3		5.91	0.25							
	6.7		5.95	0.25							
	7.1		6.00	0.3							
	7.5		6.00	0.3							
	7.9		5.97	0.3							
	8.3		5.94	0.28							
	8.7		5.95	0.25							
	9.1		5.90	0.2							
	9.5		5.82	0.08							
RWS	9.9		5.75	0							
	10.9		5.43								
	12.5		5.07								
	12.9		5.04								
BF	13.1		4.94								
S	17.6		4.60								
TOTALS:											

End of Measurement	Time:	Gage Reading: _____ ft	CALCULATIONS PERFORMED BY:	CALCULATIONS CHECKED BY:

R2Cross RESULTS

Stream Name: Williams Gulch
Stream Locations: At Bliss SWA, Hwy 14
Fieldwork Date: 07/11/2023
Cross-section: 1
Observers: Birch Sidell
Coordinate System: UTM Zone 13
X (easting): 436363
Y (northing): 4506510
Date Processed: 09/21/2023
Slope: 0.0268
Discharge: Entered Value: 2.43 (cfs)
Computation method: Ferguson VPE
R2Cross data filename: Williams Gulch XS 1 - 07-11-2023 Q=2.434.xlsx
R2Cross version: 2.0.2

LOCATION



ANALYSIS RESULTS

Habitat Criteria Results

Bankfull top width (ft) = 8.54

	Habitat Criteria	Discharge (cfs) Meeting Criteria
Mean Depth (ft)	0.2	1.0
Percent Wetted Perimeter (%)	50.0	0.01
Mean Velocity (ft/s)	1.0	2.29

STAGING TABLE

Feature	Distance to Water (ft)	Top Width (ft)	Mean Depth (ft)	Maximum Depth (ft)	Area (sq ft)	Wetted Perimeter (ft)	Percent Wetted Perimeter	Hydraulic Radius (ft)	Manning's n	Mean Velocity (ft/s)	Discharge (cfs)
Bankfull	5.85	8.54	0.56	0.66	4.78	9.31	100.0	0.51	0.06	2.41	11.52
	5.87	8.51	0.55	0.64	4.64	9.27	99.55	0.5	0.07	2.33	10.82
	5.88	8.49	0.53	0.63	4.5	9.23	99.09	0.49	0.07	2.25	10.15
	5.9	8.47	0.52	0.61	4.36	9.19	98.64	0.47	0.07	2.18	9.49
	5.92	8.44	0.5	0.59	4.22	9.15	98.19	0.46	0.07	2.1	8.86
	5.93	8.42	0.48	0.58	4.08	9.1	97.73	0.45	0.07	2.02	8.25
	5.95	8.39	0.47	0.56	3.94	9.06	97.28	0.44	0.07	1.94	7.66
	5.97	8.37	0.45	0.54	3.81	9.02	96.83	0.42	0.07	1.86	7.09
	5.98	8.35	0.44	0.53	3.67	8.98	96.37	0.41	0.07	1.79	6.55
	6.0	8.32	0.42	0.51	3.53	8.93	95.92	0.4	0.08	1.71	6.03
	6.01	8.3	0.41	0.49	3.39	8.89	95.47	0.38	0.08	1.63	5.53
	6.03	8.28	0.39	0.48	3.26	8.85	95.01	0.37	0.08	1.55	5.05
	6.05	8.25	0.38	0.46	3.12	8.81	94.56	0.35	0.08	1.47	4.59
	6.06	8.23	0.36	0.45	2.98	8.77	94.11	0.34	0.08	1.39	4.16
	6.08	8.2	0.35	0.43	2.85	8.72	93.65	0.33	0.09	1.32	3.75
	6.1	8.18	0.33	0.41	2.71	8.68	93.2	0.31	0.09	1.24	3.36
	6.11	8.16	0.32	0.4	2.58	8.64	92.75	0.3	0.09	1.16	3.0
	6.13	8.13	0.3	0.38	2.44	8.6	92.29	0.28	0.1	1.09	2.65
Waterline	6.14	8.11	0.29	0.37	2.35	8.57	91.97	0.27	0.1	1.03	2.42
	6.15	8.11	0.28	0.36	2.31	8.55	91.84	0.27	0.1	1.01	2.33
	6.16	8.1	0.27	0.35	2.18	8.52	91.46	0.26	0.1	0.93	2.03
	6.18	8.08	0.25	0.33	2.04	8.48	91.08	0.24	0.11	0.86	1.75
	6.2	8.07	0.24	0.31	1.91	8.45	90.7	0.23	0.11	0.78	1.5
	6.21	8.06	0.22	0.3	1.78	8.41	90.32	0.21	0.12	0.71	1.26
	6.23	8.05	0.2	0.28	1.64	8.38	89.94	0.2	0.13	0.64	1.05

	6.25	8.04	0.19	0.26	1.51	8.34	89.56	0.18	0.14	0.57	0.86
	6.26	8.03	0.17	0.25	1.38	8.31	89.18	0.17	0.15	0.5	0.69
	6.28	8.01	0.16	0.23	1.25	8.27	88.8	0.15	0.16	0.44	0.54
	6.3	8.0	0.14	0.21	1.11	8.24	88.42	0.14	0.17	0.37	0.41
	6.31	7.99	0.12	0.2	0.98	8.2	88.03	0.12	0.19	0.31	0.31
	6.33	7.98	0.11	0.18	0.85	8.16	87.65	0.1	0.21	0.25	0.21
	6.34	7.97	0.09	0.17	0.72	8.13	87.27	0.09	0.24	0.2	0.14
	6.36	7.66	0.08	0.15	0.59	7.81	83.82	0.08	0.28	0.16	0.09
	6.38	6.84	0.07	0.13	0.47	6.97	74.82	0.07	0.3	0.13	0.06
	6.39	6.1	0.06	0.12	0.36	6.2	66.58	0.06	0.34	0.11	0.04
	6.41	5.28	0.05	0.1	0.27	5.35	57.48	0.05	0.39	0.09	0.02
	6.43	4.69	0.04	0.08	0.19	4.75	50.96	0.04	0.47	0.06	0.01
	6.44	3.94	0.03	0.07	0.12	3.98	42.68	0.03	0.61	0.04	0.0
	6.46	3.07	0.02	0.05	0.06	3.09	33.23	0.02	0.88	0.02	0.0
	6.48	1.56	0.01	0.03	0.02	1.57	16.87	0.01	1.25	0.01	0.0
	6.49	0.49	0.01	0.02	0.0	0.49	5.27	0.01	1.92	0.0	0.0

This Manning's roughness coefficient was calculated based on velocity estimates from the Ferguson VPE method

MODEL SUMMARY

Measured Flow (Qm) =	2.43	(cfs)
Calculated Flow (Qc) =	2.43	(cfs)
(Qm-Qc)/Qm * 100 =	0.24%	
Measured Waterline (WLm) =	6.16	(ft)
Calculated Waterline (WLc) =	6.14	(ft)
(WLm-WLc)/WLm * 100 =	0.21%	
Max Measured Depth (Dm) =	0.4	(ft)
Max Calculated Depth (Dc) =	0.37	(ft)
(Dm-Dc)/Dm * 100 =	8.07%	
Mean Velocity =	1.03	(ft/s)
Manning's n =	0.099	
0.4 * Qm =	0.97	(cfs)
2.5 * Qm =	6.08	(cfs)

FIELD DATA

Feature	Station (ft)	Rod Height (ft)	Water depth (ft)	Velocity (ft/s)
	0	5.6		
Bankfull	0.75	5.84		
Waterline	1.1	6.15	0	
	1.15	6.43	0.32	
	1.5	6.51	0.39	
	1.9	6.49	0.34	
	2.3	6.4	0.23	
	2.7	6.48	0.31	
	3.1	6.46	0.32	
	3.5	6.49	0.32	
	3.9	6.44	0.3	
	4.3	6.37	0.2	
	4.7	6.5	0.31	
	5.1	6.46	0.25	
	5.5	6.43	0.24	
	5.9	6.36	0.25	
	6.3	6.37	0.3	
	6.7	6.4	0.25	
	7.1	6.39	0.25	
	7.5	6.45	0.4	
	7.9	6.49	0.4	
	8.3	6.46	0.3	
	8.7	6.37	0.25	
	9.1	6.35	0.2	
Waterline	9.2	6.16	0	
Bankfull	9.3	5.85		
	9.7	5.75		
	10.3	5.25		
	11.2	5.06		

COMPUTED FROM MEASURED FIELD DATA

Wetted Perimeter (ft)	Water Depth (ft)	Area (ft^2)	Discharge (cfs)	Percent Discharge
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.28	0.32	0.06	0.07	2.73
0.36	0.39	0.15	0.15	6.23
0.4	0.34	0.14	0.14	5.79
0.41	0.23	0.09	0.1	3.92
0.41	0.31	0.12	0.13	5.28
0.4	0.32	0.13	0.13	5.45
0.4	0.32	0.13	0.13	5.45
0.4	0.3	0.12	0.12	5.11
0.41	0.2	0.08	0.08	3.41
0.42	0.31	0.12	0.13	5.28
0.4	0.25	0.1	0.1	4.26
0.4	0.24	0.1	0.1	4.09
0.41	0.25	0.1	0.1	4.26
0.4	0.3	0.12	0.12	5.11
0.4	0.25	0.1	0.1	4.26
0.4	0.25	0.1	0.1	4.26
0.4	0.4	0.16	0.17	6.81
0.4	0.4	0.16	0.17	6.81
0.4	0.3	0.12	0.12	5.11
0.41	0.25	0.1	0.1	4.26
0.4	0.2	0.05	0.05	2.13
0.21	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

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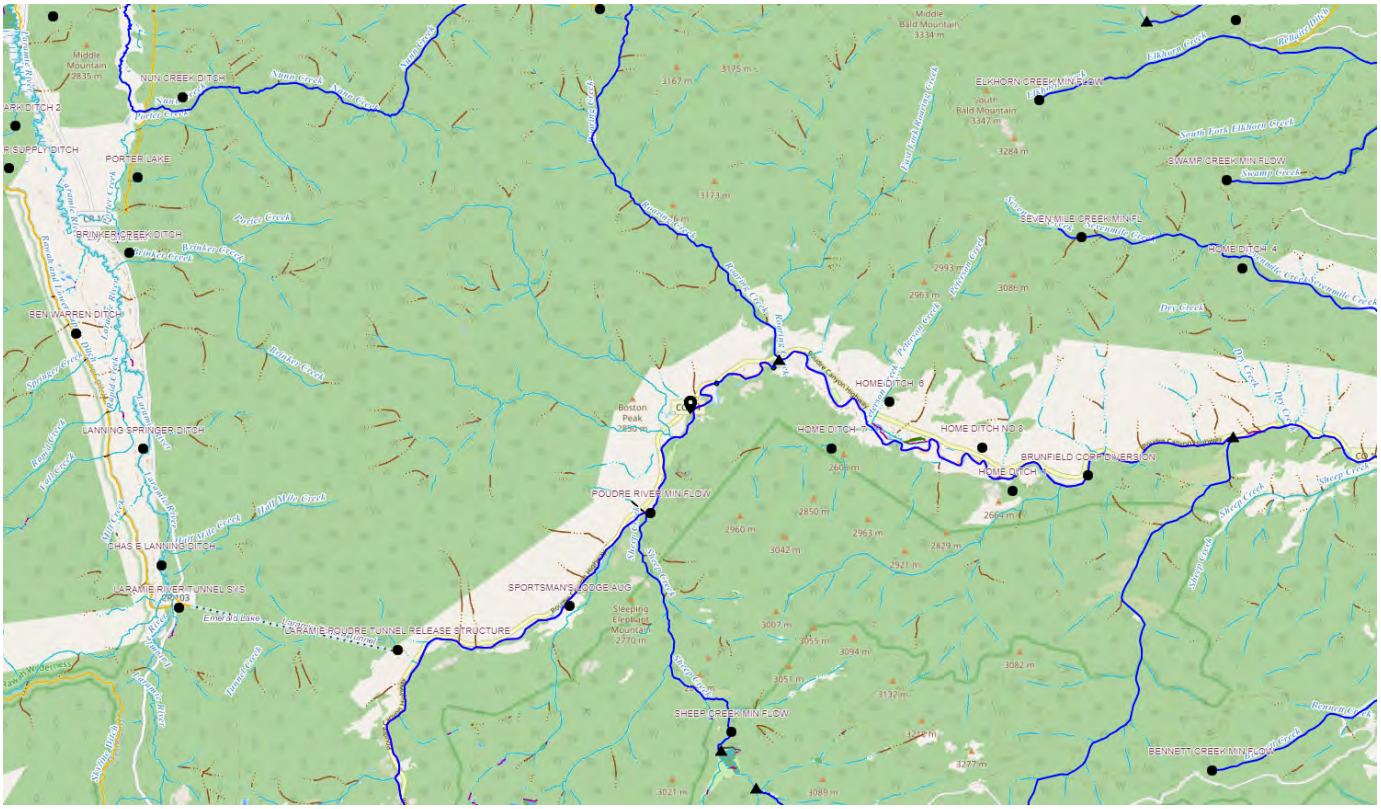
"The Colorado Water Conservation Board makes no representations about the use of the software contained in the R2Cross platform for any purpose besides that for which it was designed. To the maximum extent permitted by applicable law, all information, modeling results, and software are provided “as is” without warranty or condition of any kind, including all implied warranties or conditions of merchantability, or fitness for a particular purpose. The user assumes all responsibility for the accuracy and suitability of this program for a specific application. In no event shall the Colorado Water Conservation Board or any state agency, official or employee be liable for any direct, indirect, punitive, incidental, special, consequential damages or any damages whatsoever including, without limitation, damages for loss of use, data, profits, or savings arising from the implementation, reliance on, or use of or inability to use the R2Cross platform.

R2Cross RESULTS

Stream Name: Williams Gulch
Stream Locations: At Bliss SWA, Hwy 14
Fieldwork Date: 07/11/2023
Cross-section: 2
Observers: Birch Sidell
Coordinate System: UTM Zone 13
X (easting): 436347
Y (northing): 4506448
Date Processed: 09/21/2023
Slope: 0.0126
Discharge: Entered Value: 2.43 (cfs)
Computation method: Ferguson VPE
R2Cross data filename: Williams Gulch XS 2 - 07-11-2023 Q=2.434.xlsx
R2Cross version: 2.0.2

LOCATION



ANALYSIS RESULTS

Habitat Criteria Results

Bankfull top width (ft) = 11.58

	Habitat Criteria	Discharge (cfs) Meeting Criteria
Mean Depth (ft)	0.2	1.78
Percent Wetted Perimeter (%)	50.0	0.12
Mean Velocity (ft/s)	1.0	1.39

STAGING TABLE

Feature	Distance to Water (ft)	Top Width (ft)	Mean Depth (ft)	Maximum Depth (ft)	Area (sq ft)	Wetted Perimeter (ft)	Percent Wetted Perimeter	Hydraulic Radius (ft)	Manning's n	Mean Velocity (ft/s)	Discharge (cfs)
Bankfull	4.95	11.58	0.77	1.05	8.91	12.13	100.0	0.73	0.03	4.4	39.23
	4.99	11.47	0.74	1.01	8.49	11.99	98.88	0.71	0.03	4.26	36.18
	5.04	11.32	0.7	0.96	7.92	11.81	97.37	0.67	0.03	4.07	32.24
	5.09	11.07	0.66	0.91	7.36	11.54	95.12	0.64	0.03	3.9	28.7
	5.14	10.76	0.63	0.86	6.81	11.2	92.31	0.61	0.03	3.74	25.49
	5.19	10.44	0.6	0.81	6.28	10.86	89.51	0.58	0.03	3.58	22.49
	5.24	10.13	0.57	0.76	5.77	10.52	86.71	0.55	0.03	3.41	19.67
	5.29	9.81	0.54	0.71	5.27	10.18	83.91	0.52	0.03	3.24	17.05
	5.34	9.5	0.5	0.66	4.79	9.84	81.11	0.49	0.03	3.05	14.61
	5.39	9.18	0.47	0.61	4.32	9.5	78.31	0.45	0.03	2.86	12.36
	5.44	8.88	0.44	0.56	3.87	9.17	75.63	0.42	0.04	2.66	10.28
	5.49	8.68	0.4	0.51	3.43	8.94	73.69	0.38	0.04	2.42	8.28
	5.54	8.47	0.35	0.46	3.0	8.7	71.75	0.34	0.04	2.16	6.49
	5.59	8.26	0.31	0.41	2.58	8.47	69.81	0.3	0.04	1.89	4.89
	5.64	8.06	0.27	0.36	2.17	8.23	67.87	0.26	0.04	1.61	3.5
Waterline	5.69	7.85	0.23	0.31	1.78	8.0	65.93	0.22	0.05	1.31	2.33
	5.74	7.64	0.18	0.26	1.39	7.76	63.99	0.18	0.05	1.0	1.39
	5.79	7.3	0.14	0.21	1.01	7.4	61.03	0.14	0.06	0.71	0.72
	5.84	6.74	0.1	0.16	0.66	6.82	56.26	0.1	0.08	0.44	0.29
	5.89	5.8	0.06	0.11	0.35	5.85	48.26	0.06	0.12	0.22	0.08
	5.94	3.62	0.03	0.06	0.1	3.64	29.98	0.03	0.21	0.07	0.01
	5.99	0.72	0.01	0.01	0.01	0.72	5.95	0.01	0.44	0.02	0.0

This Manning's roughness coefficient was calculated based on velocity estimates from the Ferguson VPE method

MODEL SUMMARY

Measured Flow (Qm) =	2.43	(cfs)
Calculated Flow (Qc) =	2.38	(cfs)
(Qm-Qc)/Qm * 100 =	2.38%	
Measured Waterline (WLm) =	5.75	(ft)
Calculated Waterline (WLc) =	5.69	(ft)
(WLm-WLc)/WLm * 100 =	1.01%	
Max Measured Depth (Dm) =	0.3	(ft)
Max Calculated Depth (Dc) =	0.31	(ft)
(Dm-Dc)/Dm * 100 =	-4.31%	
Mean Velocity =	1.34	(ft/s)
Manning's n =	0.046	
0.4 * Qm =	0.97	(cfs)
2.5 * Qm =	6.08	(cfs)

FIELD DATA

Feature	Station (ft)	Rod Height (ft)	Water depth (ft)	Velocity (ft/s)
	0	4.36		
	0.8	4.61		
Bankfull	1.5	4.95		
Waterline	2.3	5.74	0	
	2.7	5.96	0.28	
	3.1	5.98	0.3	
	3.5	5.93	0.22	
	3.9	5.97	0.28	
	4.3	5.91	0.25	
	4.7	5.94	0.25	
	5.1	5.82	0.2	
	5.5	5.87	0.2	
	5.9	5.91	0.25	
	6.3	5.91	0.25	
	6.7	5.95	0.25	
	7.1	6	0.3	
	7.5	6	0.3	
	7.9	5.97	0.3	
	8.3	5.94	0.28	
	8.7	5.95	0.25	
	9.1	5.9	0.2	
	9.5	5.82	0.08	
Waterline	9.9	5.75	0	
	10.9	5.43		
	12.8	5.07		
	12.9	5.04		
Bankfull	13.1	4.94		
	17.6	4.6		

COMPUTED FROM MEASURED FIELD DATA

Wetted Perimeter (ft)	Water Depth (ft)	Area (ft^2)	Discharge (cfs)	Percent Discharge
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.46	0.28	0.11	0.15	6.31
0.4	0.3	0.12	0.16	6.76
0.4	0.22	0.09	0.12	4.96
0.4	0.28	0.11	0.15	6.31
0.4	0.25	0.1	0.14	5.63
0.4	0.25	0.1	0.14	5.63
0.42	0.2	0.08	0.11	4.5
0.4	0.2	0.08	0.11	4.5
0.4	0.25	0.1	0.14	5.63
0.4	0.25	0.1	0.14	5.63
0.4	0.25	0.1	0.14	5.63
0.4	0.3	0.12	0.16	6.76
0.4	0.3	0.12	0.16	6.76
0.4	0.3	0.12	0.16	6.76
0.4	0.28	0.11	0.15	6.31
0.4	0.25	0.1	0.14	5.63
0.4	0.2	0.08	0.11	4.5
0.41	0.08	0.03	0.04	1.8
0.41	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

DISCLAIMER

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Discharge Measurement Summary

Site name	Williams2
Site number	071123
Operator(s)	Kb
File name	Williams2_20230711-200044.ft
Comment	

Start time	7/11/2023 7:38 PM
End time	7/11/2023 8:00 PM
Start location latitude	40.707
Start location longitude	-105.753
Calculations engine	FlowTracker2

Sensor type	Top Setting
Handheld serial number	FT2H2113010
Probe serial number	FT2P2114008
Probe firmware	1.30
Handheld software	1.6.4

# Stations	Avg interval (s)	Total discharge (ft³/s)
21	40	2.434

Total width (ft)	Total area (ft²)	Wetted Perimeter (ft)
8.000	3.080	8.309

Mean SNR (dB)	Mean depth (ft)	Mean velocity (ft/s)
37.316	0.385	0.790

Mean temp (°F)	Max depth (ft)	Max velocity (ft/s)
62.446	0.500	1.096

Discharge Uncertainty		
Category	**ISO**	**IVE**
Accuracy	1.0%	1.0%
Depth	0.4%	6.0%
Velocity	0.4%	5.2%
Width	0.1%	0.1%
Method	1.9%	
# Stations	2.4%	
Overall	**3.2%**	**8.0%**

Discharge equation	Mid Section
Discharge uncertainty	IVE
Discharge reference	Rated

Data Collection Settings	
Salinity	0.000 PSS-78
Temperature	-
Sound speed	-
Mounting correction	0.000 %

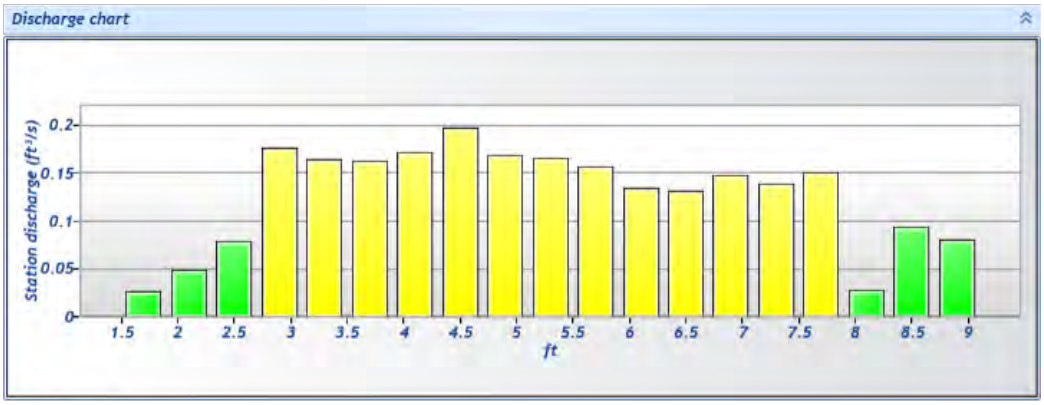
Summary overview

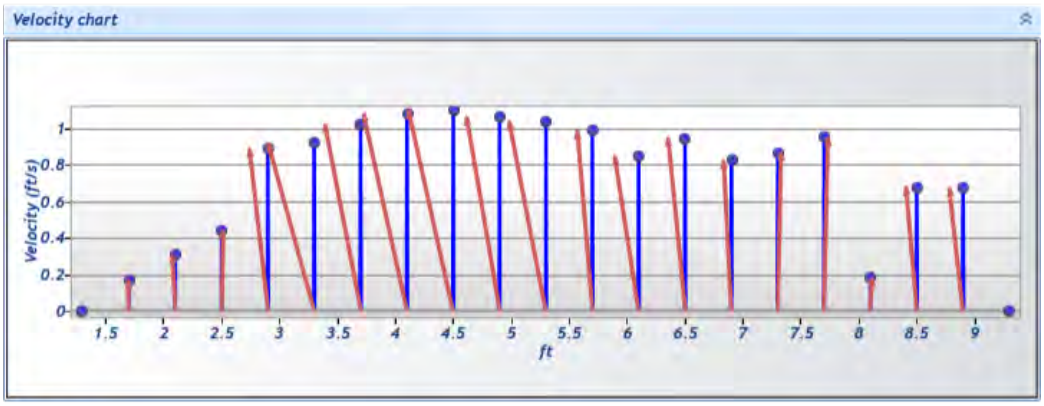
No changes were made to this file
Quality control warnings

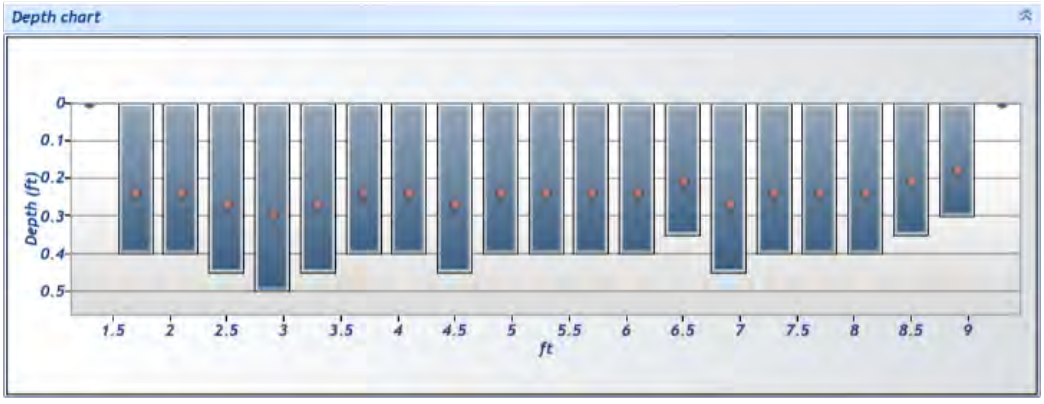
Discharge Measurement Summary

Site name	Williams2
Site number	071123
Operator(s)	Kb
File name	Williams2_20230711-200044.ft
Comment	

Station Warning Settings	
Station discharge OK	Station discharge < 5.000%
Station discharge caution	5.000% >= Station discharge < 10.000%
Station discharge warning	Station discharge >= 10.000%







Discharge Measurement Summary

Site name	Williams2
Site number	071123
Operator(s)	Kb
File name	Williams2_20230711-200044.ft
Comment	

Measurement results

St#	Time	Location (ft)	Method	Depth (ft)	%Depth	Measured Depth (ft)	Samples	Velocity (ft/s)	Correction	Mean Velocity (ft/s)	Area (ft²)	Flow (ft³/s)	%Q	
0	7:38 PM	1.300	None	0.000	0.000	0.000	0	0.000		0.168	0.000	0.000	0.000	✓
1	7:38 PM	1.700	0.6	0.400	0.600	0.240	39	0.168	1.000	0.168	0.160	0.027	1.105	✓
2	7:39 PM	2.100	0.6	0.400	0.600	0.240	51	0.308	1.000	0.308	0.160	0.049	2.025	✓
3	7:40 PM	2.500	0.6	0.450	0.600	0.270	60	0.441	1.000	0.441	0.180	0.079	3.259	✓
4	7:41 PM	2.900	0.6	0.500	0.600	0.300	47	0.886	1.000	0.886	0.200	0.177	7.279	✓
5	7:43 PM	3.300	0.6	0.450	0.600	0.270	62	0.917	1.000	0.917	0.180	0.165	6.779	✓
6	7:44 PM	3.700	0.6	0.400	0.600	0.240	80	1.021	1.000	1.021	0.160	0.163	6.708	✓
7	7:45 PM	4.100	0.6	0.400	0.600	0.240	80	1.075	1.000	1.075	0.160	0.172	7.066	✓
8	7:46 PM	4.500	0.6	0.450	0.600	0.270	62	1.096	1.000	1.096	0.180	0.197	8.105	✓
9	7:47 PM	4.900	0.6	0.400	0.600	0.240	68	1.060	1.000	1.060	0.160	0.170	6.964	✓
10	7:48 PM	5.300	0.6	0.400	0.600	0.240	63	1.037	1.000	1.037	0.160	0.166	6.815	✓
11	7:49 PM	5.700	0.6	0.400	0.600	0.240	64	0.987	1.000	0.987	0.160	0.158	6.489	✓
12	7:50 PM	6.100	0.6	0.400	0.600	0.240	63	0.847	1.000	0.847	0.160	0.136	5.569	✓
13	7:51 PM	6.500	0.6	0.350	0.600	0.210	56	0.946	1.000	0.946	0.140	0.132	5.438	✓
14	7:52 PM	6.900	0.6	0.450	0.600	0.270	63	0.821	1.000	0.821	0.180	0.148	6.070	✓
15	7:54 PM	7.300	0.6	0.400	0.600	0.240	66	0.867	1.000	0.867	0.160	0.139	5.697	✓
16	7:55 PM	7.700	0.6	0.400	0.600	0.240	65	0.947	1.000	0.947	0.160	0.152	6.224	✓
17	7:56 PM	8.100	0.6	0.400	0.600	0.240	80	0.181	1.000	0.181	0.160	0.029	1.188	✓
18	7:57 PM	8.500	0.6	0.350	0.600	0.210	72	0.679	1.000	0.679	0.140	0.095	3.905	✓
19	7:58 PM	8.900	0.6	0.300	0.600	0.180	72	0.673	1.000	0.673	0.120	0.081	3.315	✓
20	8:00 PM	9.300	None	0.000	0.000	0.000	0	0.000		0.673	0.000	0.000	0.000	✓

Discharge Measurement Summary

Site name	Williams2
Site number	071123
Operator(s)	Kb
File name	Williams2_20230711-200044.ft
Comment	

Quality Control Settings	
Maximum depth change	50.000%
Maximum spacing change	100.000%
SNR threshold	10.000 dB
Standard error threshold	0.033 ft/s
Spike threshold	10.000%
Maximum velocity angle	20.000 deg
Maximum tilt angle	5.000 deg

Quality control warnings

St#	Time	Location (ft)	Method	Depth (ft)	%Depth	Measured Depth (ft)	Warnings
4	7:41 PM	2.900	0.6	0.500	0.600	0.300	Boundary Interference
5	7:43 PM	3.300	0.6	0.450	0.600	0.270	Velocity Angle > QC
6	7:44 PM	3.700	0.6	0.400	0.600	0.240	High % Spikes