West Divide Water Conservancy District Project Water Right Yield Study

9/26/2023

Prepared for:
West Divide Water Conservancy District

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BACKGROUND

The West Divide Project was included as a priority in the Colorado River Storage Act of 1956 and provided beneficial uses of energy generation, domestic, industrial, irrigation, stock watering, and municipal. The contemplated project included several large storage structures on the Crystal River as well as conveyance infrastructure to deliver water from the Crystal River to the Divide Creek area where additional reservoirs were proposed to store the water, in particular Kendig Reservoir, located on West Divide Creek. The project was changed by the Department of Interior in 1966 where the focus shifted from supplemental irrigation to providing water for oil shale development. The project was authorized by Congress in 1968 but was not funded. The project was deemed economically infeasible with the federal government withdrawing support in 1982. Diligence has continued for these conditional water rights by the Colorado River District and West Divide Water Conservancy District in order to retain their quantity and priority to potentially utilize them for other purposes. For example, structures augmented by WDWCD are decreed as alternate points of diversion to the Avalanche Canal and Siphon or Fourmile Canal and Siphon water right which gives these otherwise junior water rights a 1957 appropriation date.

Due to local concerns during diligence proceedings in 2011, all West Divide Project water rights in the Crystal River basin have been abandoned by the Water Court. Conditional water rights for the West Divide project remain on tributaries south of the Colorado River from Fourmile Creek to Battlement Creek. This study was undertaken to determine what yield would be available from these water rights as well as how the water can be utilized as a source of fill for conditional storage rights outside of the Crystal River basin. This study was conducted utilizing Colorado Water Plan grant funds with matching contributions from West Divide Water Conservancy District (POGG1-PDAA 201800000572 and 202000003016).

INTRODUCTION

Conditional water rights were sought for the West Divide Project in 1957. The contemplated project included several large storage structures on the Crystal River (Yank Creek, Thompson Creek, Placita, and Osgood Reservoirs) as well as conveyance infrastructure to several storage structures south of the Colorado River in the vicinity of the Divide Creek drainage. The direct flow water rights for the conveyance structures that are the subject of this yield study are shown in **Table 1** while the related West Divide Project storage water rights are shown in **Table 2**.

Table 1: West Divide Canal and Horsethief Canal Water Rights

WDID	Structure Name	Structure Type	Water Source	Adj Date	Appr Date	Decreed Use(s)	Net Cond (cfs)	Net APEX Cond (cfs)
4501090	W DIVIDE PROJ HORSETHIEF	Ditch	BEAVER CREEK	7/9/1965	4/22/1957	123489	0	50
4501091		Ditch	CACHE CREEK	7/9/1965	4/22/1957	123489	0	50
4501092		Ditch	EAST MAMM CREEK	7/9/1965	4/22/1957	123489	0	50
4501093		Ditch	WEST DIVIDE CREEK	7/9/1965	4/22/1957	123489	550	0
4501103		Ditch	BATTLEMENT CREEK	7/9/1965	4/22/1957	12489	0	50
4500817	W DIVIDE PROJ W DIV CNL	Ditch	BALDY CREEK	7/9/1965	4/22/1957	123489	50	0
4501089		Ditch	GARFIELD CREEK	7/9/1965	4/22/1957	123489	50	0
4501096		Ditch	EAST DIVIDE CREEK	7/9/1965	4/22/1957	123489	200	0

Table 2: West Divide Project Conditional Storage Right Related to West Divide and Horsethief Canals

WDID	Structure Name	Structure Type	Water Source	Adj Date	Appr Date	Decreed Use(s)	Net Cond (AF)	Net APEX Cond (AF)
4503588	W DIVIDE PROJ W MAMM RES	Reservoir	WEST MAMM CREEK	7/9/1965	4/22/1957	12489P	6500	0
4503585	W DIVIDE PROJ KENDIG RES	Reservoir	WEST DIVIDE CREEK	7/9/1965	4/22/1957	12489P	15450	0
4503585	W DIVIDE PROJ KENDIG RES	Reservoir	WEST DIVIDE CREEK	12/31/1979	6/18/1979	1458PQ	2610	0

Delivery canals were contemplated to divert flows from the Crystal River basin to the Divide Creek area where water could continue to be diverted at tributary crossings for subsequent storage in Kendig or Mamm Creek Reservoirs. All of the drainages south of the Colorado River are over appropriated and have water rights senior to the mainstem Colorado River Cameo call near Palisade, CO. This results in administrative calls being placed in most years, even in the wettest of years, once the hydrograph has declined and junior users are physically and legally water supply limited.

Following West Divide Project water right diligence in Case No. 11CW93, which abandoned the Crystal River sourced water rights, the yield of the remaining project water rights in the absence of Crystal River supplies is largely unknown. This study was conducted to quantify the yield of the

tributary direct flow water rights to other West Divide project components by conducting stream gaging measurements over several seasons.

The following tasks (Table 3) were proposed to be completed in the study:

Table 3: Description of Work Tasks

Task No.	Task Description
1	Increase streamflow monitoring in the Divide Creek area to understand water yield and exchange potential from conditional water rights tributary to the Colorado River.
2	Create statistical relationships between tributary gages and the long-term West Divide Creek Raven gage.
3	Quantify the anticipated additional yield to Kendig Reservoir from these additional supplies.
4	Re-evaluate canal alignments to optimize yield and delivery.
5	Evaluate potential service areas that would be created by these supplies.

METHODOLOGY

Methodologies utilized to conduct this study are described by task in the following sections.

Task 1 – Increase Streamflow Monitoring

At the time this project was proposed, there was only one stream gage available on a tributary south of the Colorado River, the West Divide Creek Raven gage operated by the Colorado Division of Water Resources. In recent years, additional gages have been installed on tributaries to the Colorado River with a gage added on lower Divide Creek (USGS Site Number: 09090785). The locations of streamflow monitoring are shown in the attached **Figure 1**. Because previous studies have identified alternative locations for Kendig reservoir, the monitoring locations were positioned to be above most irrigation diversions and in alignment with the preferred Kendig Reservoir alignment.

Colorado River Engineering (CRE) worked with the Bureau of Land Management (BLM) to locate the majority the stream gages on public land. In instances where public land was not available, CRE worked with private landowners and the Water District 45 Commissioner to find suitable locations to place gages and conduct streamflow measurements. At each site, a staff gage and housing for a pressure transducer (In-Situ Level Troll 500) to continuously monitor the water level in the stream were installed (**Figure 2**). Rating curves (stage vs. discharge) were developed by physically measuring the streamflow with a pygmy meter or Price AA meter at various flow rates (**Figure 3**) and developing a relationship between water depth (stage) and the flow rate (discharge). The developed rating curves allow for derivation of the flow rate from continuously

monitored water level in the stream using the site-specific relationship between stage and discharge.

Figure 2: Staff gage and Pressure Transducer Housing.

Figure 3: Measuring streamflow on Cache Creek – 2023

Due to the nature of small, mountainous streams, some sites had issues with staff gages moving as rocks and other materials in the stream shifted during runoff seasons. This was particularly an issue in 2023 which saw sustained, high runoff on these tributary streams and significantly

altered the channel geometries. Flow conditions were largely unsafe for monitoring streamflows in 2023; however, best efforts were made to determine the yield to the West Divide project water rights. Additionally, no winter flows were measured as icing in the stream can damage the pressure transducers. Due to the snowmelt driven nature of these streams, spring runoff is the typical period when water would reliably be available to the West Divide Project (WDP) water rights.

Task 2 – Statistical Relationships with Long-Term West Divide Creek Raven Gage

Once the tributary flow datasets were derived, the tributary flow was plotted against the flow measured at the West Divide Creek Raven gage to determine if statistical relationships were strong enough to derive longer time series of tributary flow data and quantify the yield over longer time periods. The analysis looked at relationships of all daily data as well as daily data parsed by month to attempt to improve the statistical relationships.

Task 3 – Quantify the Yield to Kendig Reservoir

The streamflow physically and legally available to the WDP water rights was analyzed using two methods. The first method looked at each decreed water right in the basin and reduced the available flow by the amount decreed to water rights senior in priority to the WDP rights. Alternatively, the available flow also was derived based on all reported diversions from the senior water rights on each tributary. If there was insufficient flow to meet either all of the decreed rights or the reported diversions, no yield was quantified in the analysis. The yield represents a highly conservative estimate of the quantity of streamflow physically and legally available to the subject water rights.

Task 4 - Re-Evaluate Canal Alignments to Optimize Yield and Delivery

Canal alignments were created for the original Kendig reservoir location. Subsequent reservoir feasibility studies conducted have prioritized an alternative location for Kendig reservoir which avoids private property and geologically unstable areas and moves the dam further upstream onto U.S. Forest Service lands (**Figure 1**). Prior to finalizing the streamflow measurement locations, an alternative canal alignment was derived based on the anticipated elevation of Kendig Reservoir. The canal alignment is shown on the attached **Figure 1**. Positioning the stream measurement locations near the canal elevation provided actual flows that may be available to the water rights without the need to account for inflow/outflows at locations downstream of where the canal would be located. While this decision made site access difficult during the spring, it provided data at the appropriate location for considering physical and legal water supply.

Task 5 – Develop Potential Service Areas that can be Created by these Supplies

Each augmentation plan decreed by WDWCD has a defined service area in which augmentation services can be provided with the supplies available. The delineation of service areas where the quantified supplies could potentially be utilized was considered in this study.

RESULTS

The results of the WDP yield study are presented herein by task. Task 1 included most of the time and effort for collecting and processing both the automated stage and manual streamflow measurements. Best efforts were made to access the sites prior to spring runoff and to continue monitoring throughout the study period to maintain the rating curve accuracy. Due to the elevation at these locations, spring conditions often included muddy or snow packed roads that were often impassible until later in the spring.

Task 1 – Increase Streamflow Monitoring

Stream gaging sites were installed at the locations described in **Table 4** and shown on **Figure 1**.

Table 4: Installed Stream Gage Site Metadata.

Name	Lat	Long	Elev (ft)	Contributing Area (mi^2)	Mean Basin Elevation (ft)
Battlement Creek	39.42724	-107.969	6960	9.12	9326
Beaver Creek	39.46112	-107.832	6995	7.77	9450
East Divide	39.40651	-107.492	7751	25	9026
Baldy Creek	39.46235	-107.492	7498	12.8	8996
Cache Creek	39.432	-107.914	7543	8.42	9816
Garfield Creek	39.47386	-107.425	7593	4.95	8838
West Divide Creek (Raven)	39.33108	-107.58	7200	64.2	8732

Table 4 shows the beginning and end date of the data monitoring period for each tributary. As mentioned previously, flow measurements were only conducted during the irrigation season as icing and freezing can damage the pressure transducers. Data files from the pressure transducers and AquaCalc used to conduct manual measurements are provided with this report. The East Mamm site was not able to be monitored because a suitable location could not be located on public land and private landowner access was not granted. East Mamm has the lowest basin mean elevation of 7,673 feet; yields from East Mamm Creek were not anticipated to be significant.

Table 5: Data Collection by Tributary

Station	Begin	End	# Manual Streamflow Measurements
Garfield	5/8/2020	7/25/2023	6
Baldy	7/9/2019	7/25/2023	8
East Divide	6/12/2019	7/25/2023	10
Cache	4/29/2020	7/25/2023	8
Beaver	5/15/2019	7/25/2023	10
Battlement	5/15/2019	7/25/2023	8

Time series of the measured flow data from each site are included in **Appendix A**.

No data are available from Beaver Creek in 2022 due to cows pulling the transducer from the stream. No data are available for Battlement Creek in 2023 due to the station being carried downstream under high water.

Task 2 – Statistical Relationships with Long-Term West Divide Creek Raven Gage

Efforts were made to correlate the streamflow data collected on each tributary to the long-term Division of Water Resources West Divide Creek Raven gage (WSDRAVCO). These analyses did not provide reliable statistical relationships to derive longer tributary flow datasets as the runoff characteristics are too varied. This is seen in **Table 3** by comparing the mean basin elevations and contributing areas. The West Divide Creek gage by far has the largest contributing area with 64.2 square miles. The next largest basin is Baldy Creek with 12.8 square miles of contributing area. Given the differences in the basin characteristics, it is not surprising that the daily gaged data do not correlate well with the Raven gage. The East Divide Creek and Baldy Creek gages had the best correlations to the West Divide Creek gage; however, given the lack of correlation on other tributaries the analysis of yield was restricted to the period of manual data collection shown in **Table 5**. The monthly correlations by tributary are provided in **Appendix B**.

Task 3 – Quantify the Yield to Kendig Reservoir

Throughout the study period, data relating the depth of water in the stream (stage) to the flow rate in cubic feet per second were collected and compiled. These relationships are referred to as "rating curves" and allow for flow estimation from the continuously measured depth of water.

The yield of these water rights was quantified using two different methods. The first reduced the flow by all decreed water rights included in the water right tabulation senior in priority to the West Divide Project rights. The second analysis looked at the diversion records available through CDSS (Colorado Decision Support System) by tributary and reduced the flow by the amount reportedly diverted by senior water rights. The quantified yield for Divide Creek accounted for

both East Divide and West Divide Creek flows and water right diversions. The quantified yield for Garfield Creek accounted for both Garfield and Baldy Creek flows and water right diversions. The annual yield results are included in **Appendix C** with the study period average summarized in **Table 6**.

Table 6: Average West Divide Project Water Right Yields – 2020-2023

West Divide Project Water Right Yields - Study Period Average								
Available Flow - Diversion Based (AF)								
	April	May	June	July	August	September	October	Total
Garfield	0	14	422	92	77	0	0	605
Divide	1837	8474	893	11	21	62	6	11305
Beaver	6	91	158	341	7	1	1	606
Cache	12	5202	1283	70	56	66	50	6739
Battlement	6	25	0	0	0	0	0	32
Total	**1861**	**13807**	**2756**	**516**	**161**	**129**	**58**	**19287**
Available Flow - Tabulation Based (AF)								
	April	May	June	July	August	September	October	Total
Garfield	0	0	0	0	0	0	0	0
Divide	31	3237	0	0	0	0	0	3269
Beaver	0	0	0	0	0	0	0	0
Cache	0	4993	825	0	0	0	0	5817
Battlement	0	0	0	0	0	0	0	0
Total	**31**	**8230**	**825**	**0**	**0**	**0**	**0**	**9086**

The results from the study indicate that on average, the flow available to these water rights ranges from 9,000 acre-feet to 19,000 acre-feet depending upon the methodology used. The tabulation-based method provides the most conservative assessment of the yield from these water rights. It is important to note that while this yield is available on average, these yields are not expected every year. Using the tabulation-based method there was no firm yield to these water rights over the study period. The majority of the quantified yield occurred in 2023 when streams ran high for an extended period with some minor flooding experienced.

The estimated capacity of Kendig Reservoir is 9,000 – 16,500 acre-feet based on previous feasibility analyses. The water rights available to fill Kendig Reservoir include the West Divide Canal rights on Garfield, Baldy, and Divide Creeks. Beaver, Cache, and Battlement Creek flows would be available to each tributary or to West Mamm Reservoir in addition to deliveries from Kendig Reservoir. Given the small yield contribution from Garfield and Baldy Creeks even in a wet year like 2023, construction of a delivery canal would likely be cost prohibitive compared to the water yield. Additional water could be available to Kendig Reservoir from East Divide Creek; however, it is more cost effective to increase storage on East Divide Creek with the Baldy Reservoir enlargement to Alsbury Reservoir and expand the existing East Divide Creek augmentation service area given the small demands on these streams.

Cost Estimation

The CWCB provides a cost estimation tool that is primarily utilized for costing Identified Projects and Processes (IPPs) in Basin Implementation Plans (BMP). The tool was utilized in this investigative study to estimate the cost of construction of these large canals for comparison to the quantified yield. Construction costs are summarized in **Table 7**, below. The cost for the West Divide Canal assumes the two lengths provided in the table with one option starting at Garfield Creek and the second option starting at East Divide Creek, a concrete check dam, a design flow rate of 300-cfs, and a synthetic liner. The Horsethief Canal cost assumes the length of 220,000 feet, a concrete check dam, a design flow of 550-cfs, and a synthetic liner.

With the firm yield of zero for the West Divide Canal water rights, the cost of $8-10 million is cost prohibitive compared to the yield. The Horsethief Canal would have the benefit of utilizing Kendig Reservoir storage as well as the tributary direct flow rights. Previous analysis found the firm yield to Kendig Reservoir to be 500 acre-feet if 1,500 acre-feet is designated as an augmentation pool with first-fill priority. The cost of canal construction would be in addition to the cost of reservoir construction, operations, and maintenance.

Table 7: Canal Construction Cost Estimates.

Structure	Upper	Lower	Length (lf)	Cost
West Divide Canal	Garfield Creek	Kendig Reservoir	165,000	$ 10,615,000
West Divide Canal	East Divide Creek	Kendig Reservoir	75,000	$ 8,176,000
Horsetheif Canal	Kendig Reservoir	Battlement Creek	220,000	$ 23,985,000

Task 4 - Re-Evaluate Canal Alignments to Optimize Yield and Delivery

The updated canal alignment with delivery to the preferred Kendig reservoir alternative is shown on **Figure 1**. This alignment was utilized for locating the stream gaging sites at locations in the vicinity of where the canal would be constructed.

Task 5 – Develop Potential Service Areas that can be Created by these Supplies

Due to the lack of firm yield to these water rights, the only service area delineated was that of the new Kendig Reservoir alignment (**Figure 4,** attached). This delineation assumes that water is delivered into the Divide Creek Highline Canal which optimizes the use of this water by allowing delivery of water supplies to West Divide Creek, Salt Creek, Alkali Creek, and Dry Hollow Creek. If simply released from the outlet, the reservoir would only serve West Divide Creek. The delineation of this service area requires further refining with input from the Division of Water Resources to ensure all controlling water rights and stream dry-up points are accurately represented.

CONCLUSIONS

Stream gaging was conducted from 2020-2023 to better understand the water yield to some of the remaining WDP water rights. The study was conducted during a particularly dry period in the Colorado River basin with the exception of 2023 (**Figure 4**). The study period water years are highlighted in orange showing below average runoff from 2020-2022 which were all less than 75% of the period of record average.

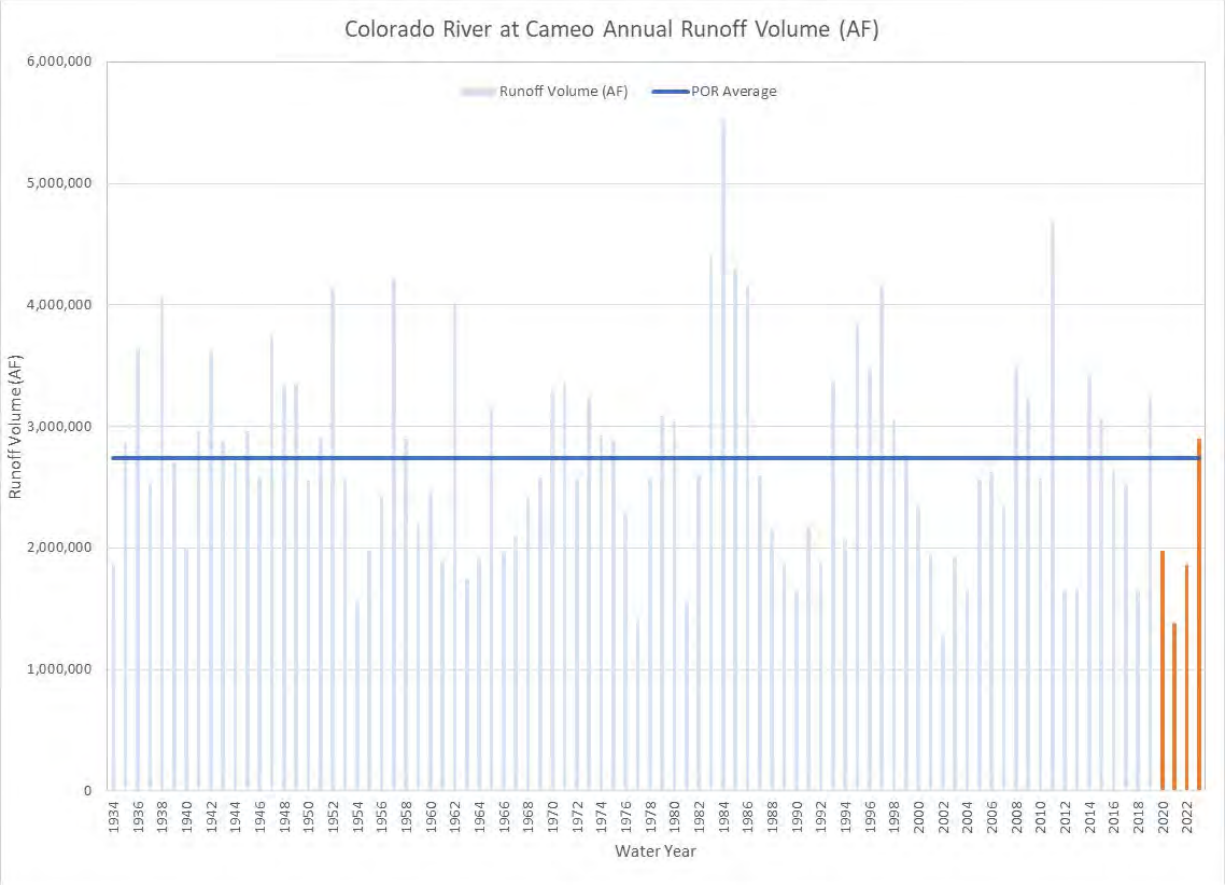

Figure 5: Colorado River at Cameo Runoff Volume Time Series

While these water rights may be of limited utility for delivery of supplies to and from Kendig Reservoir absent Crystal River supplies, there is value in the relatively senior water right priority date that future District contractees may be able to rely upon if alternative supplies can be developed for use in a local plan for augmentation. For example, these water rights can be utilized to decree junior water rights as alternate points of diversion, as is done with the Avalanche and Fourmile Canal and Siphon water rights. While this does not provide adequate protection for a Cameo call, it will protect these users from causing injury to water rights junior in priority to the WDP water rights with a 1957 priority date.

Because of the hydrologic conditions during the study period, additional data collection may be warranted to further inform the yield of these water rights as 2023 did provide adequate yield to fill Kendig Reservoir. Additional data will provide insight into the likelihood of filling Kendig Reservoir each year. This analysis could be confined to East and West Divide Creeks to better understand the available water supplies over longer time periods. Due to the cost of constructing these long delivery canals and lack of firm yield to some of the tributary water rights, construction of these projects is highly unlikely.

Overall, the demands for augmentation water on these tributaries is small and developing service areas has not yet been a priority for the District. However, the priority date of these water rights has intrinsic value to provide additional protection to District contractees junior water rights. Maintaining the status of these conditional water rights in good standing is recommended as future use of these water rights continues to be considered.

Rulison

Horsethief Canal - Battlement

Horsethief Canal - Cache

Horsethief Canal - Beaver

Cottonwood Creek

Beaver Creek

Beaver Creek

Battlement Creek

Battlement Creek

Cache Creek

Cache Creek

West Mamm Reservoir

Mamm Creek

West Mamm Creek

Middle Mamm Creek

East Mamm Creek

Horsethief Canal - E. Mamm

Garfield County

Mesa County

Divide Creek

Garfield Creek

West Divide Canal - Baldy

West Divide Canal - Garfield

Baldy Creek

Garfield Creek

Baldy Creek

East Divide Creek

West Divide Canal - E. Divide

East Divide

West Fork Baldy Creek

West Divide Creek

Clear Creek

Horsethief Canal - West Divide

Kendig Reservoir

Fourmile Creek

Beaver Dam Creek

Willow Creek

North Thompson Creek

West Divide Creek (Raven)

Pitkin County

Mesa County

Wallace Creek

Kimball Creek

West Fork Kimball Creek

Brush Creek

Buzzard Creek

West Divide Creek

N

W

E

S

5,200 0 10,400

Graphic Scale in Feet

Sources: Esri, USGS, NOAA

Map Key

<all other values> **structtype** Other Res Monitoring Locations horsethiefcanal

Ditch Pipeline Reservoir WestDivideCanal

Data Sources:
U.S. Bureau of Land Management
U.S. Census Bureau
U.S. Department of Agriculture
U.S. Geological Survey
CO Department of Water Resources
CO Department of Transportation

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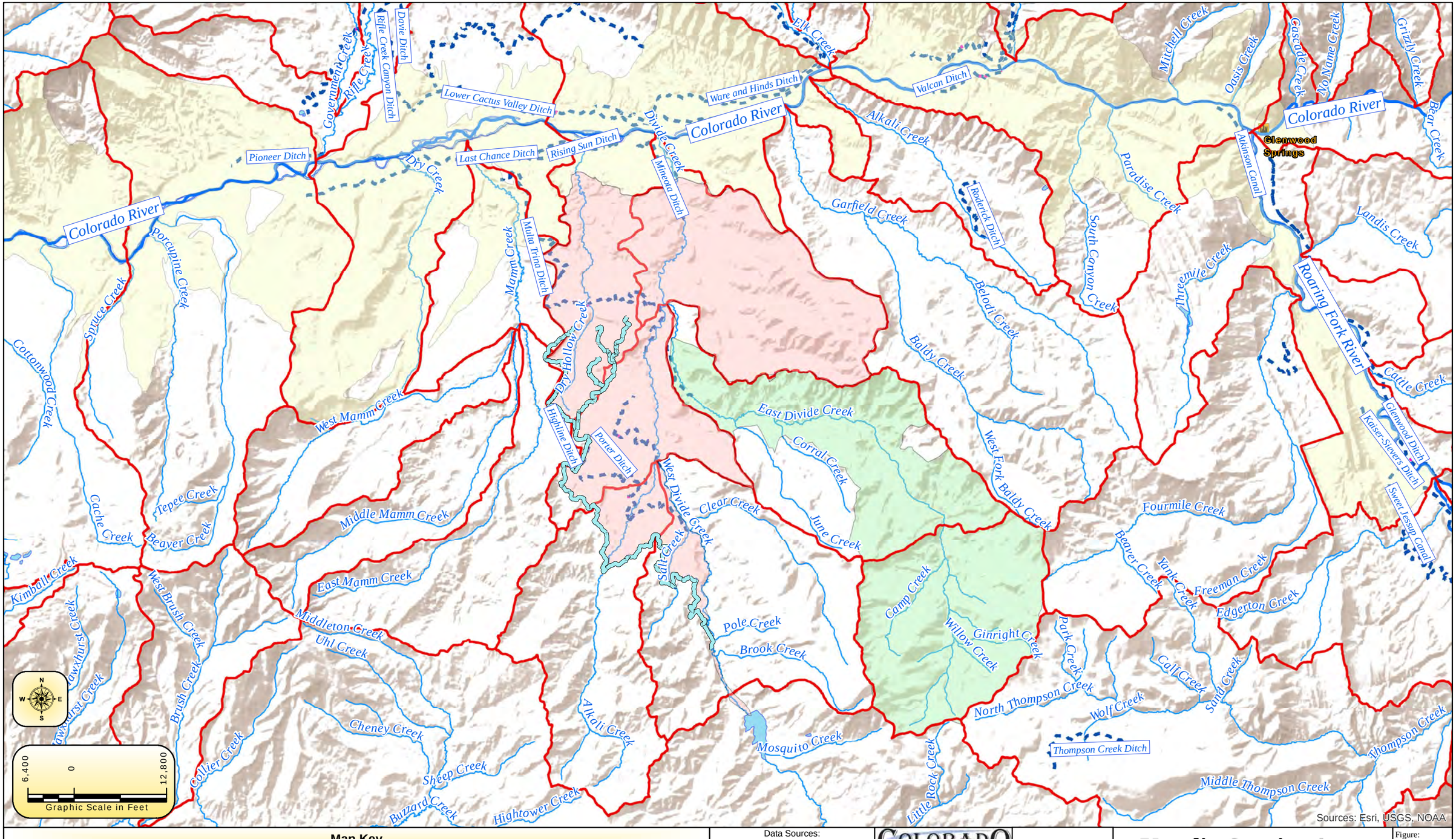
West Divide Project Water Rights and Monitoring Locations

Figure: 1

Document Name: OverviewMap.mxd

Drawn by: JT | Approved by: WR | Date: 8/10/2023

Client: 1171: WDWCD



Map Key

Highline_Ditch_All_Laterals

Highline_Ditch_All_Laterals

Kendig Service Area

NewKendigDamAlignment

ColoradoRiverServiceArea

AlsburyServiceArea

Data Sources:
U.S. Bureau of Land Management
U.S. Census Bureau
U.S. Department of Agriculture
U.S. Geological Survey
CO Department of Water Resources
CO Department of Transportation

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Kendig Service Area

Vicinity Map

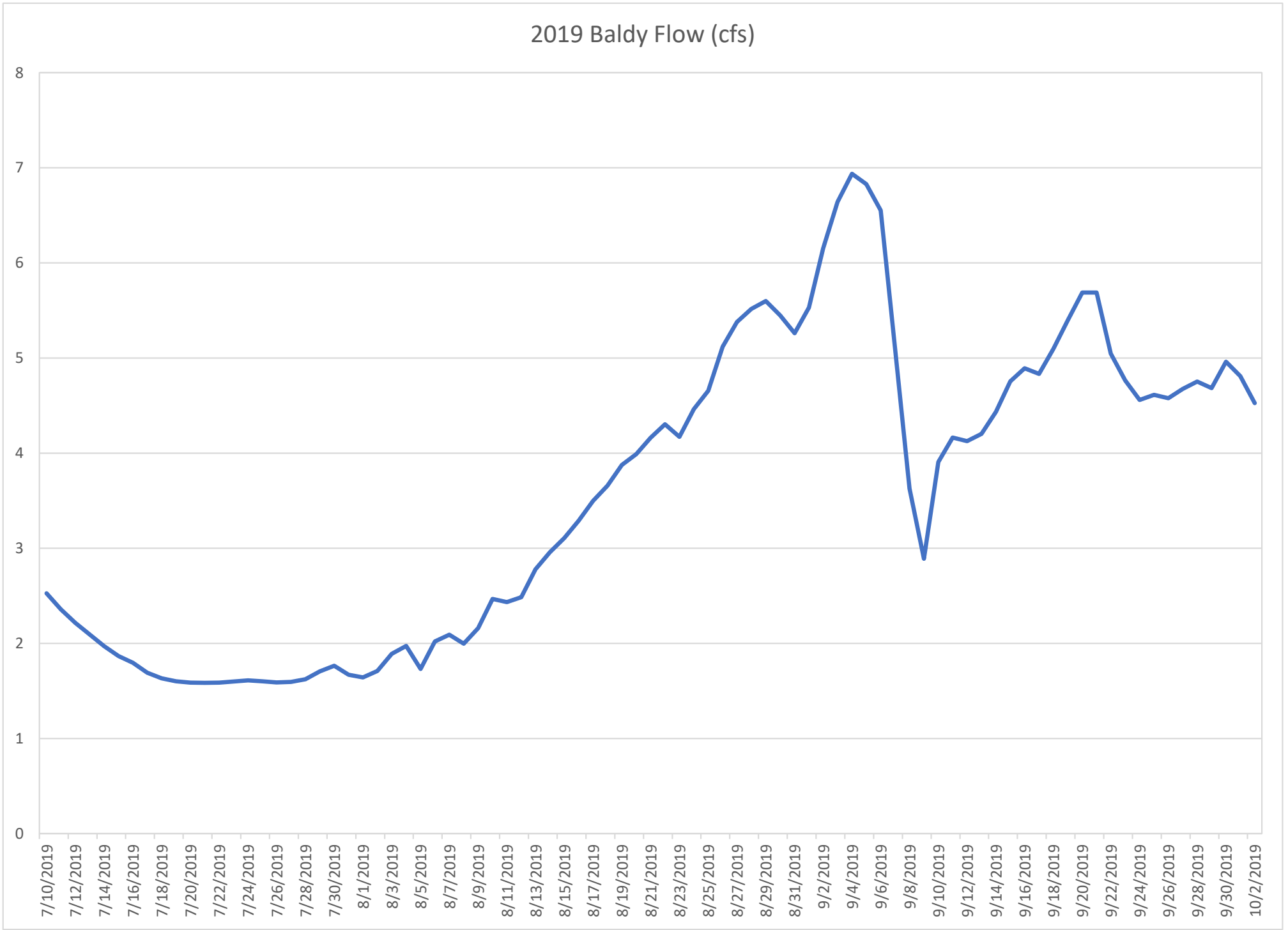
Figure: 4

Document Name: Service Areas.mxd

Drawn by: WAR | Approved by: WR | Date: 8/28/2023

Client: 1171: WD Project Yield

Appendix A: Flow Time Series By Stream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7
6
5
4
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2
1
0
7/10/2019
7/12/2019
7/14/2019
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7/18/2019
7/20/2019
7/22/2019
7/24/2019
7/26/2019
7/28/2019
7/30/2019
8/1/2019
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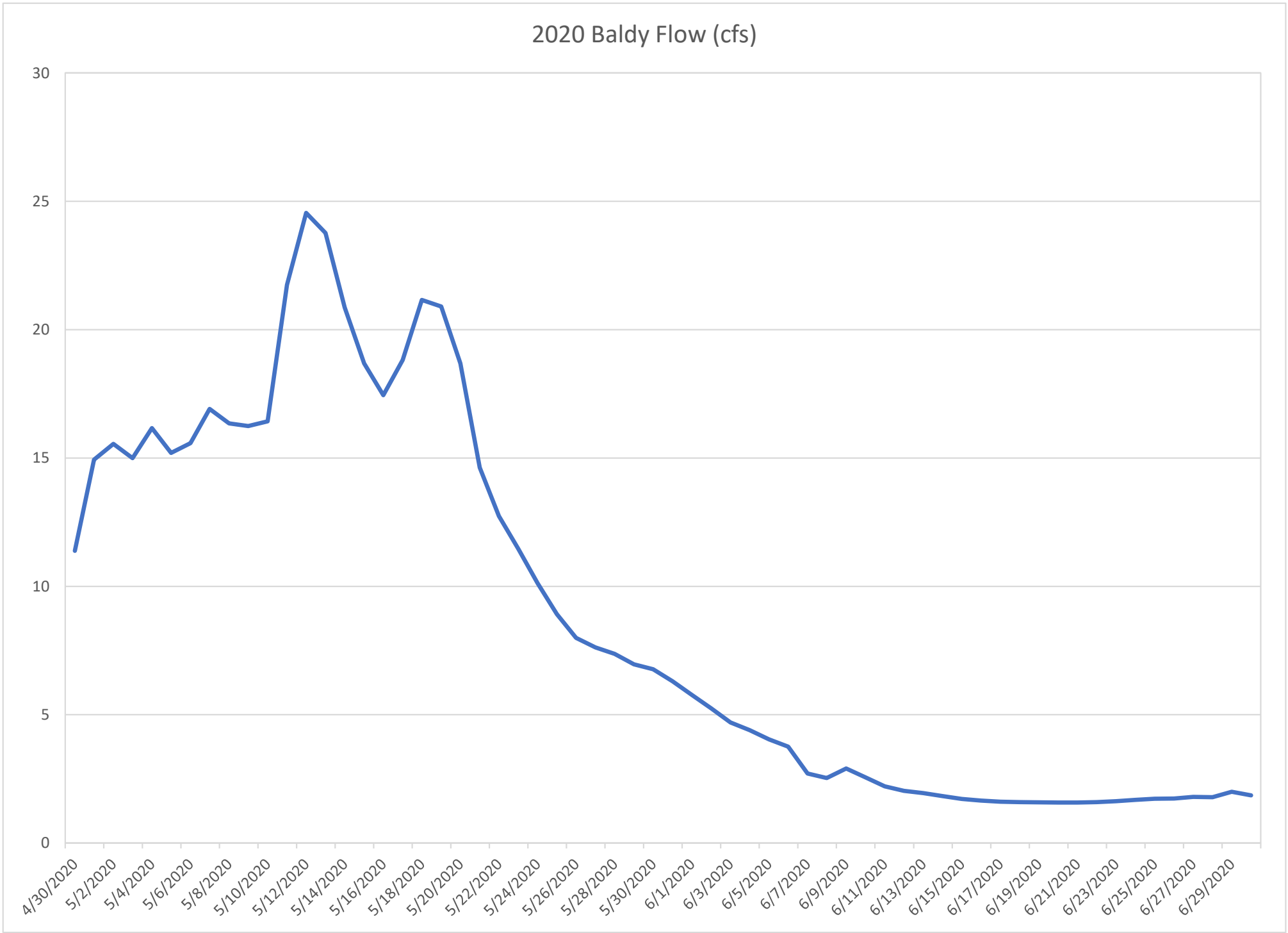
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30
25
20
15
10
5
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4/30/2020
5/2/2020
5/4/2020
5/6/2020
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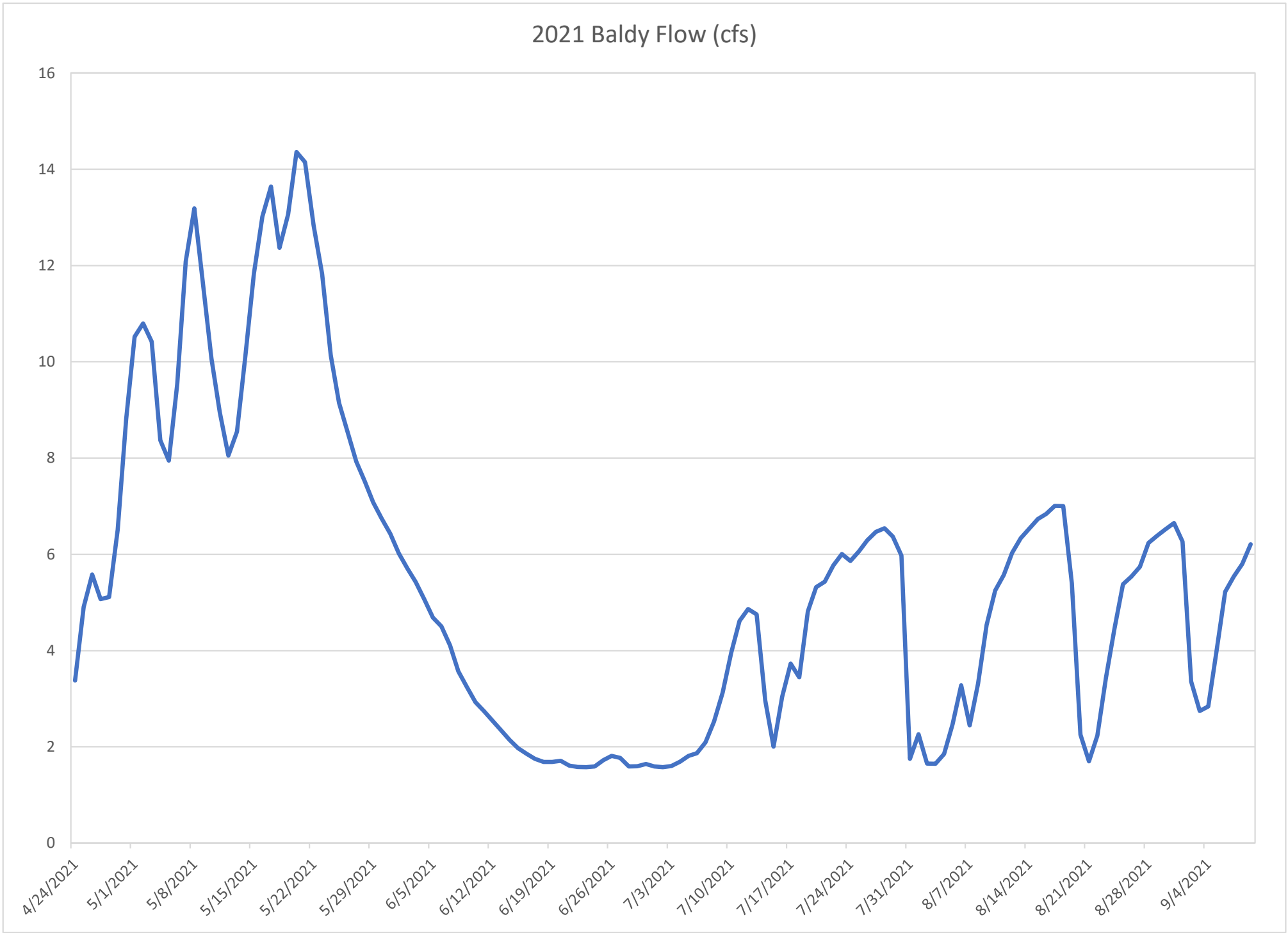
2021 Baldy Flow (cfs)
16
14
12
10
8
6
4
2
0
4/24/2021
5/1/2021
5/8/2021
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5/22/2021
5/29/2021
6/5/2021
6/12/2021
6/19/2021
6/26/2021
7/3/2021
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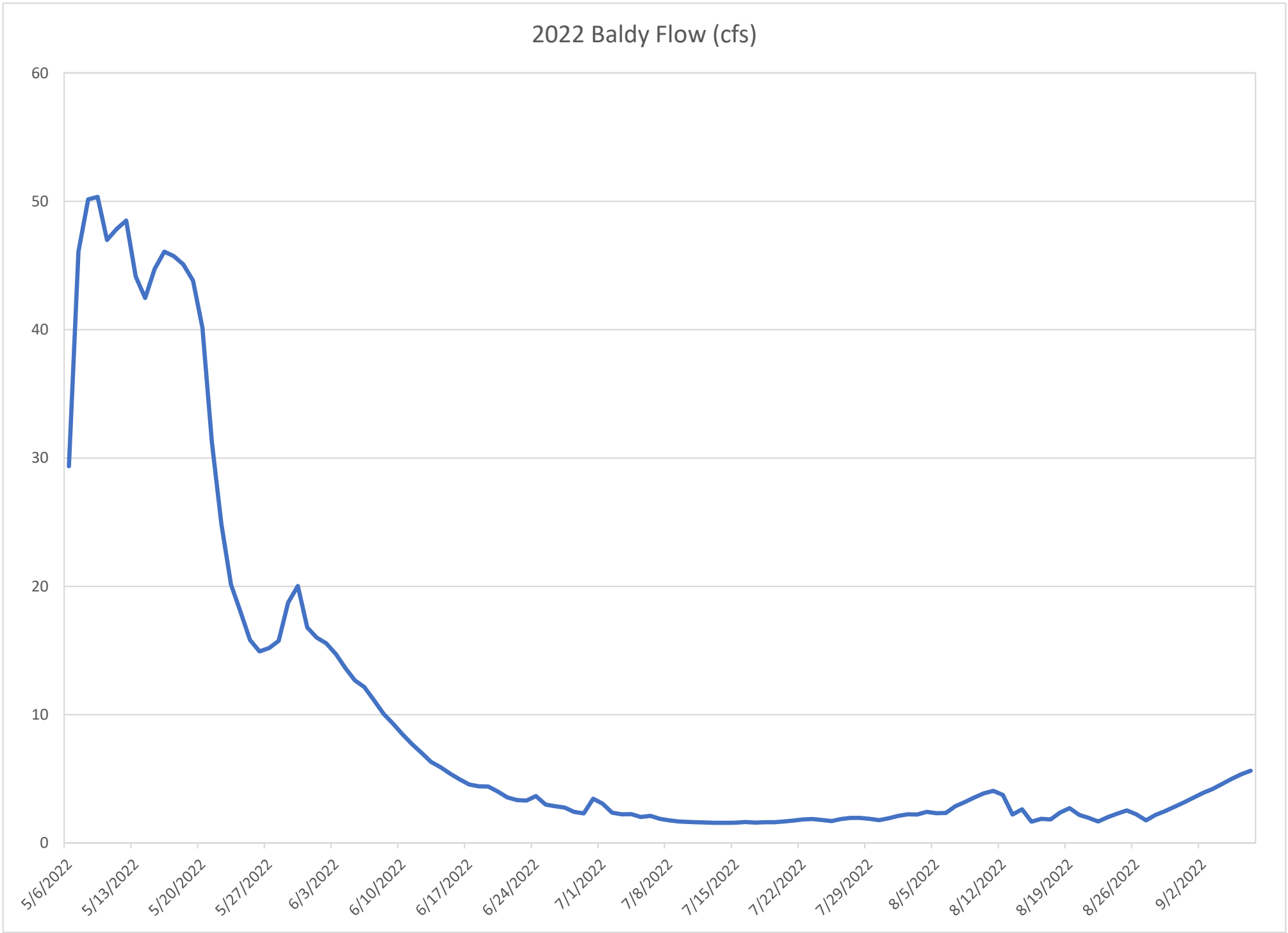
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60
50
40
30
20
10
0
5/6/2022
5/13/2022
5/20/2022
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6/3/2022
6/10/2022
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6/24/2022
7/1/2022
7/8/2022
7/15/2022
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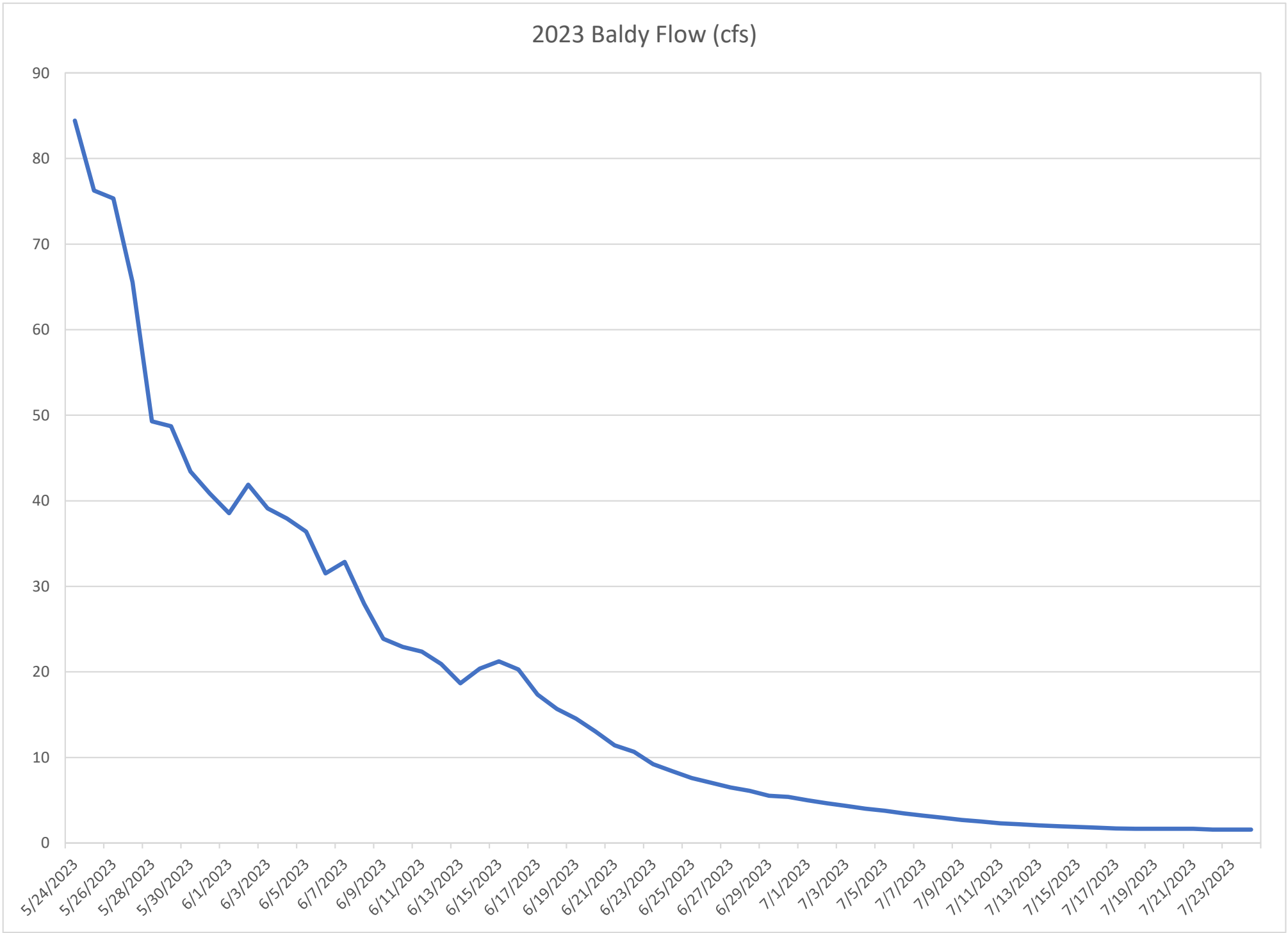
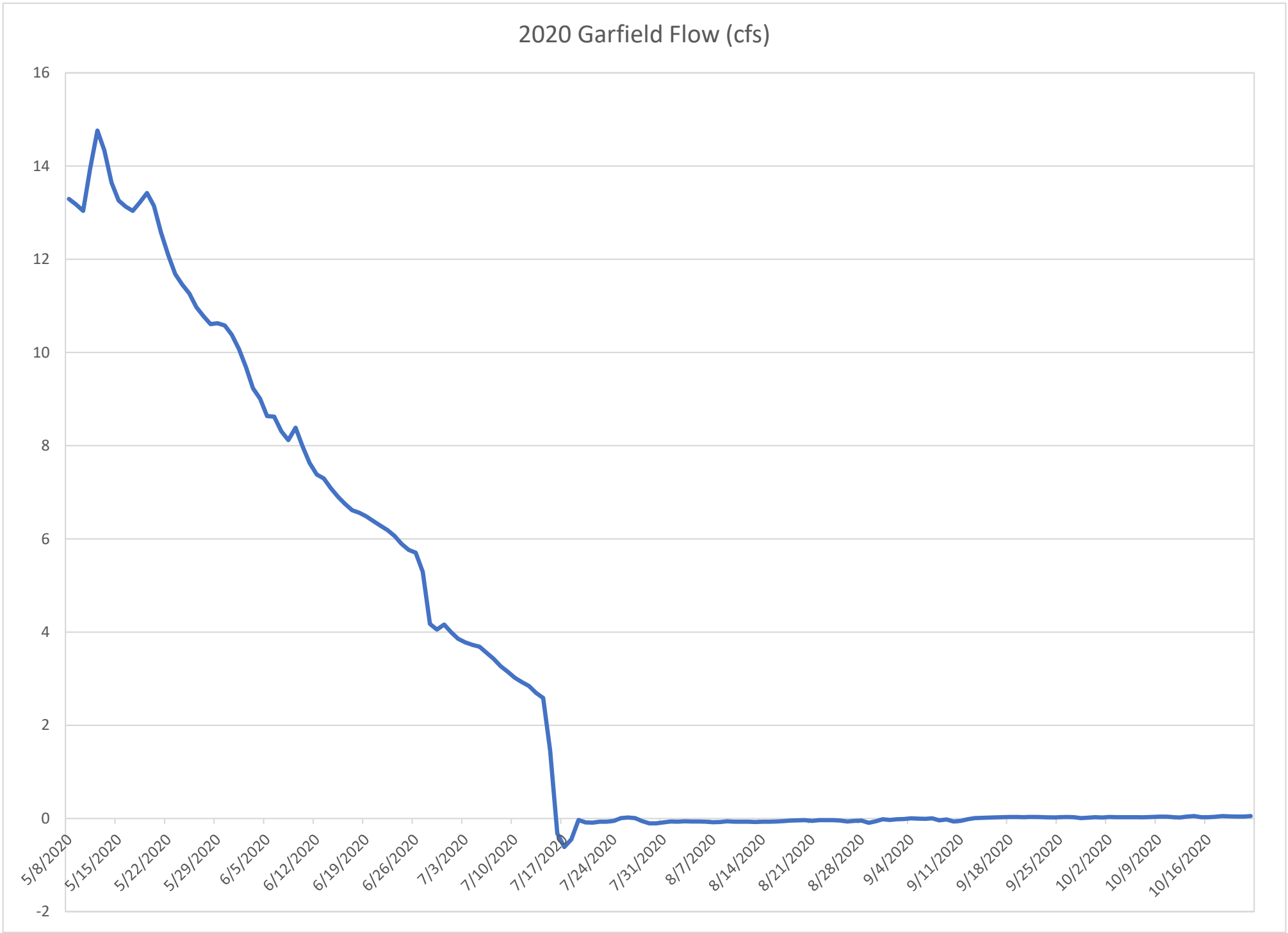
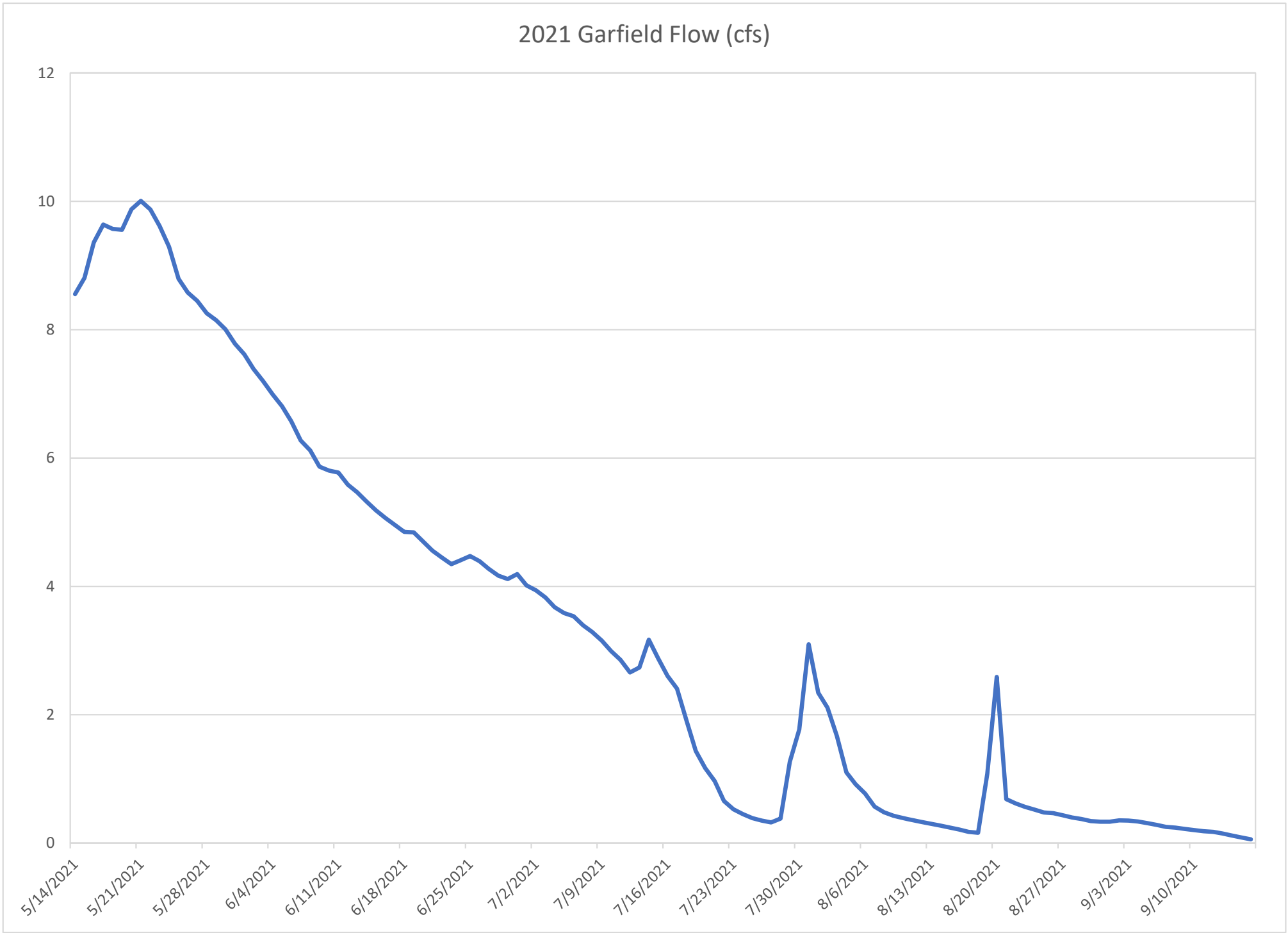
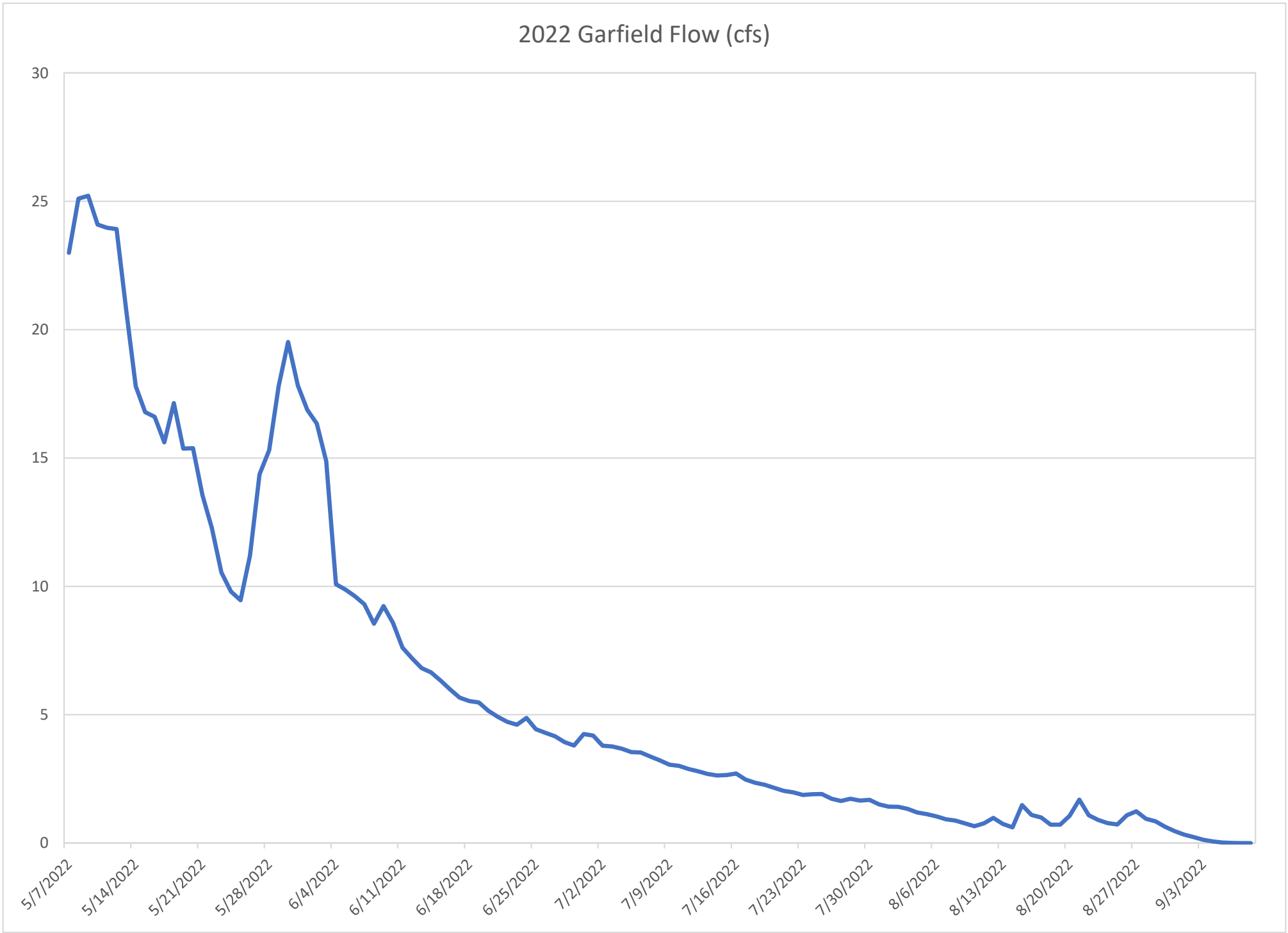
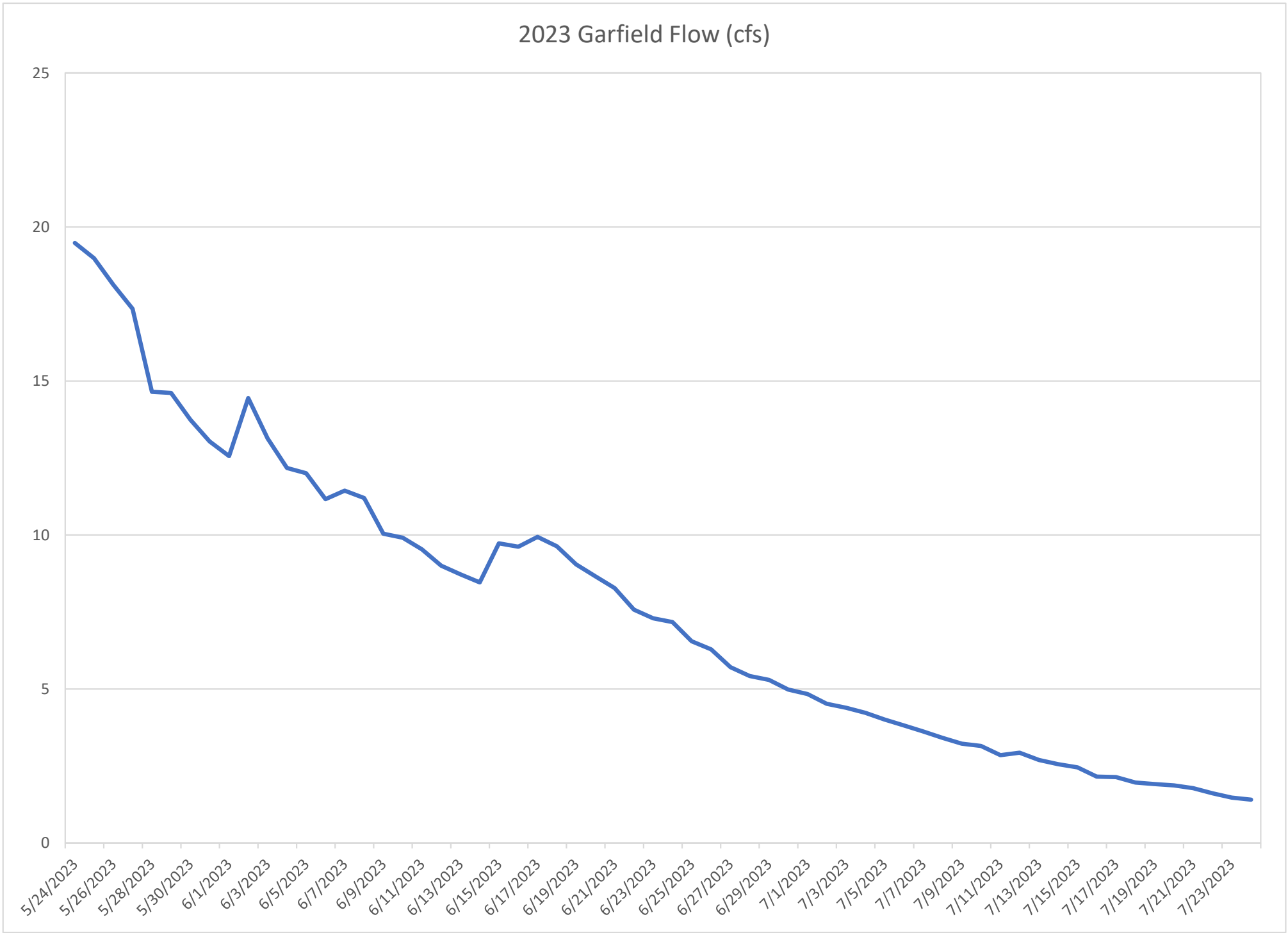
8/19/2022
8/26/2022
9/2/2022

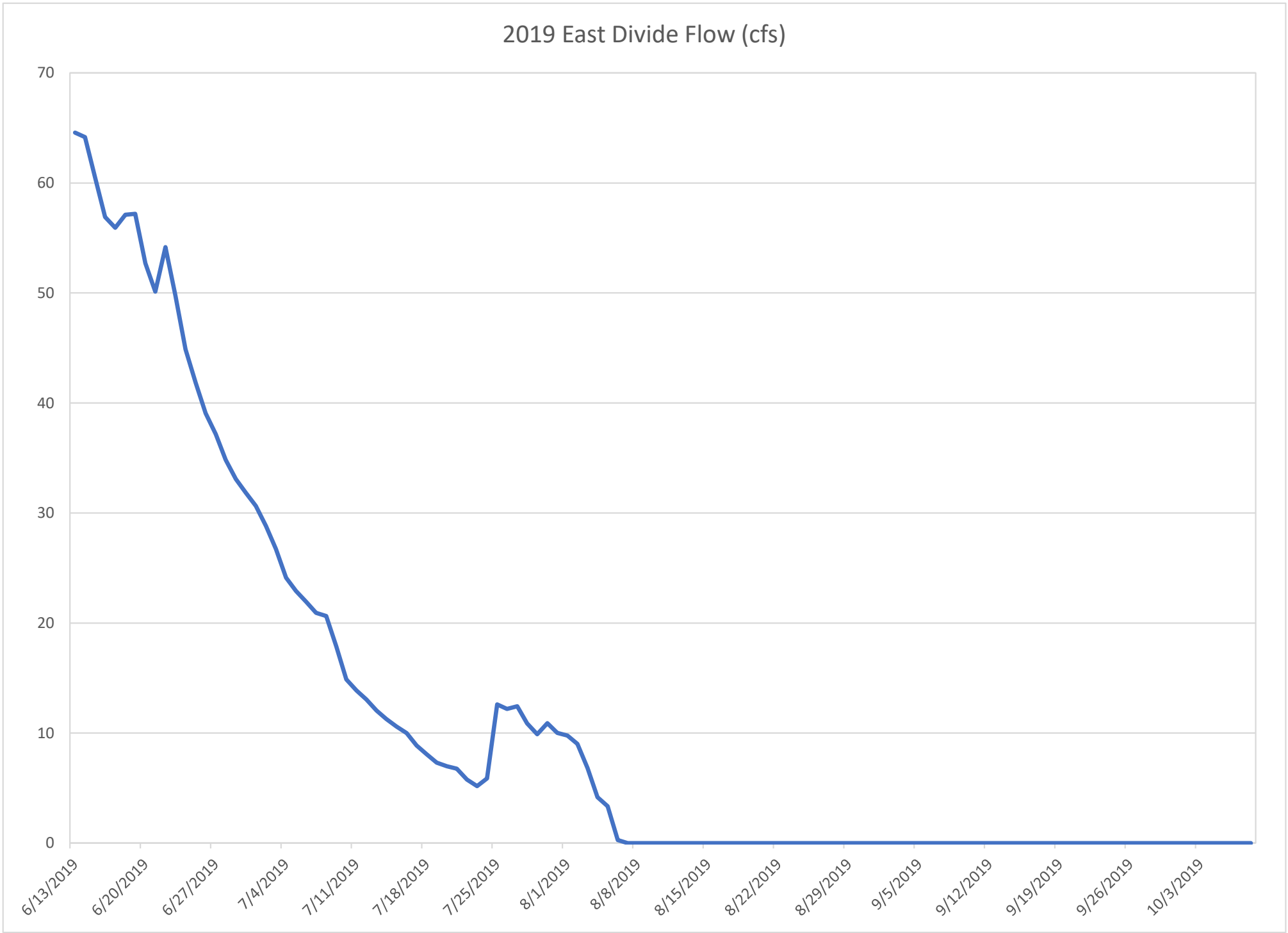

2023 Baldy Flow (cfs)
90
80
70
60
50
40
30
20
10
0
5/24/2023
5/26/2023
5/28/2023
5/30/2023
6/1/2023
6/3/2023
6/5/2023
6/7/2023
6/9/2023
6/11/2023
6/13/2023
6/15/2023
6/17/2023
6/19/2023
6/21/2023
6/23/2023
6/25/2023
6/27/2023
6/29/2023
7/1/2023
7/3/2023
7/5/2023
7/7/2023
7/9/2023
7/11/2023
7/13/2023
7/15/2023
7/17/2023
7/19/2023
7/21/2023
7/23/2023

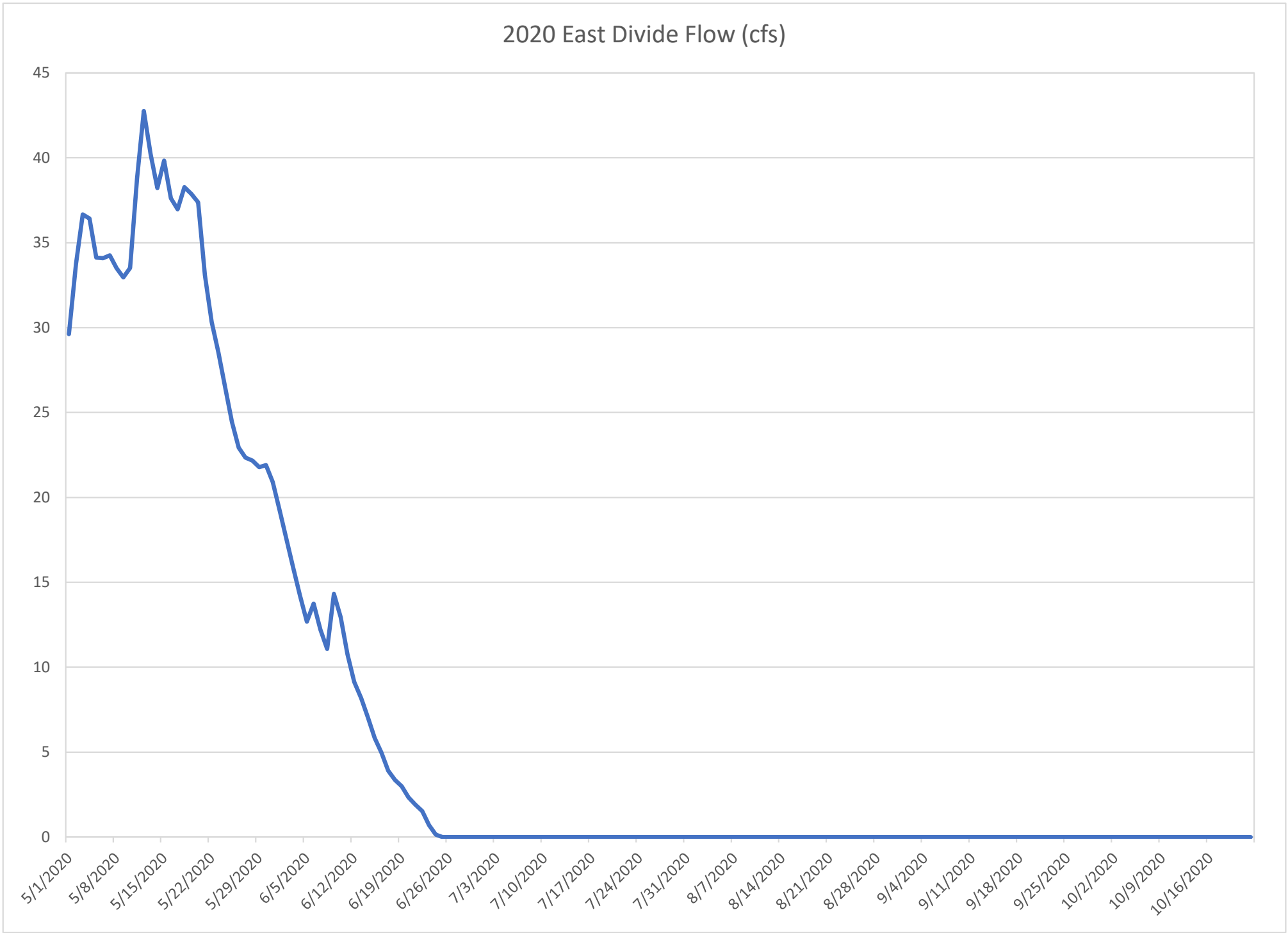

2020 Garfield Flow (cfs)
16
14
12
10
8
6
4
2
0
-2
5/8/2020
5/15/2020
5/22/2020
5/29/2020
6/5/2020
6/12/2020
6/19/2020
6/26/2020
7/3/2020
7/10/2020
7/17/2020
7/24/2020
7/31/2020
8/7/2020
8/14/2020
8/21/2020
8/28/2020
9/4/2020
9/11/2020
9/18/2020
9/25/2020
10/2/2020
10/9/2020
10/16/2020

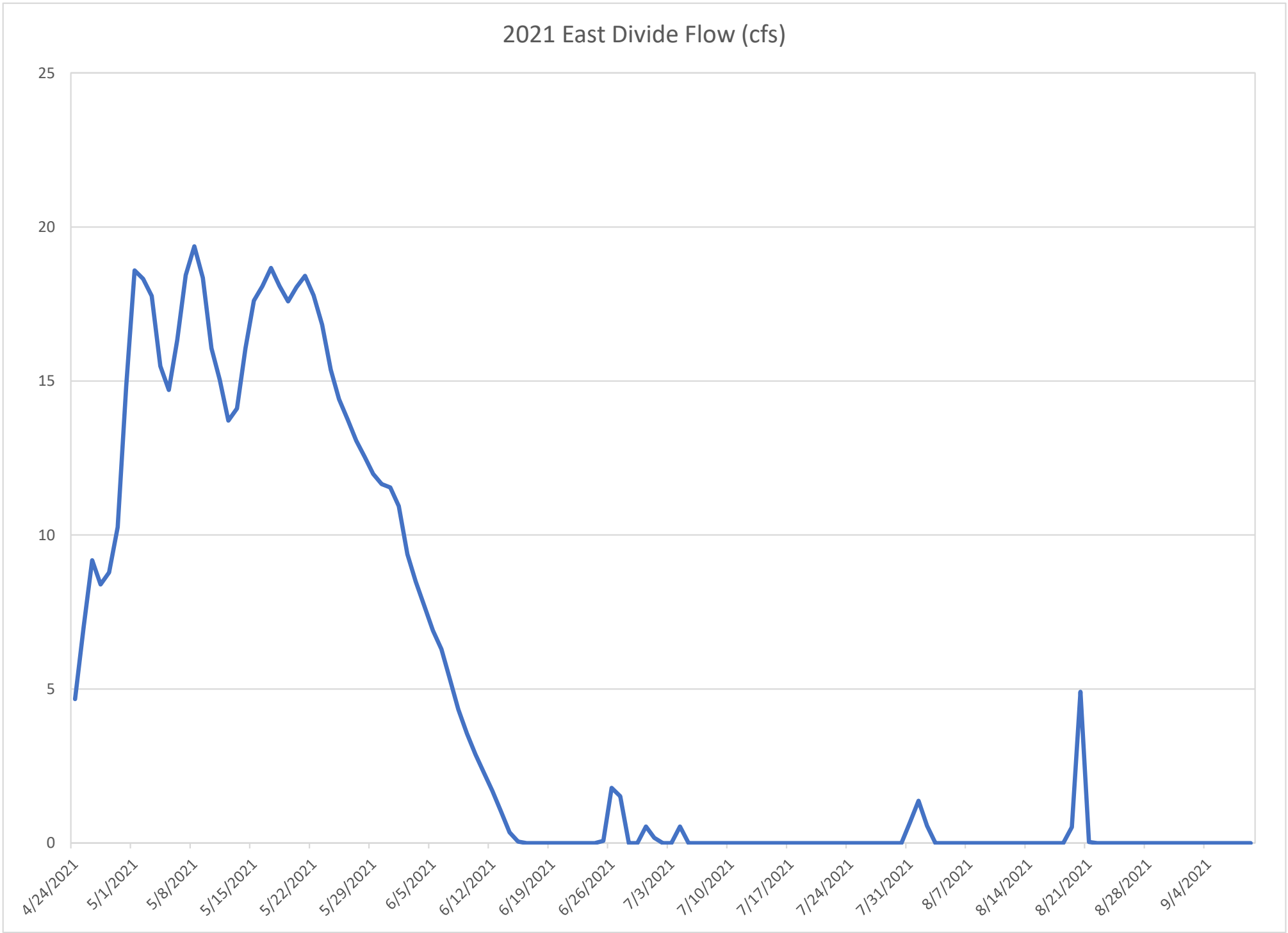

2021 Garfield Flow (cfs)
12
10
8
6
4
2
0
5/14/2021
5/21/2021
5/28/2021
6/4/2021
6/11/2021
6/18/2021
6/25/2021
7/2/2021
7/9/2021
7/16/2021
7/23/2021
7/30/2021
8/6/2021
8/13/2021
8/20/2021
8/27/2021
9/3/2021
9/10/2021

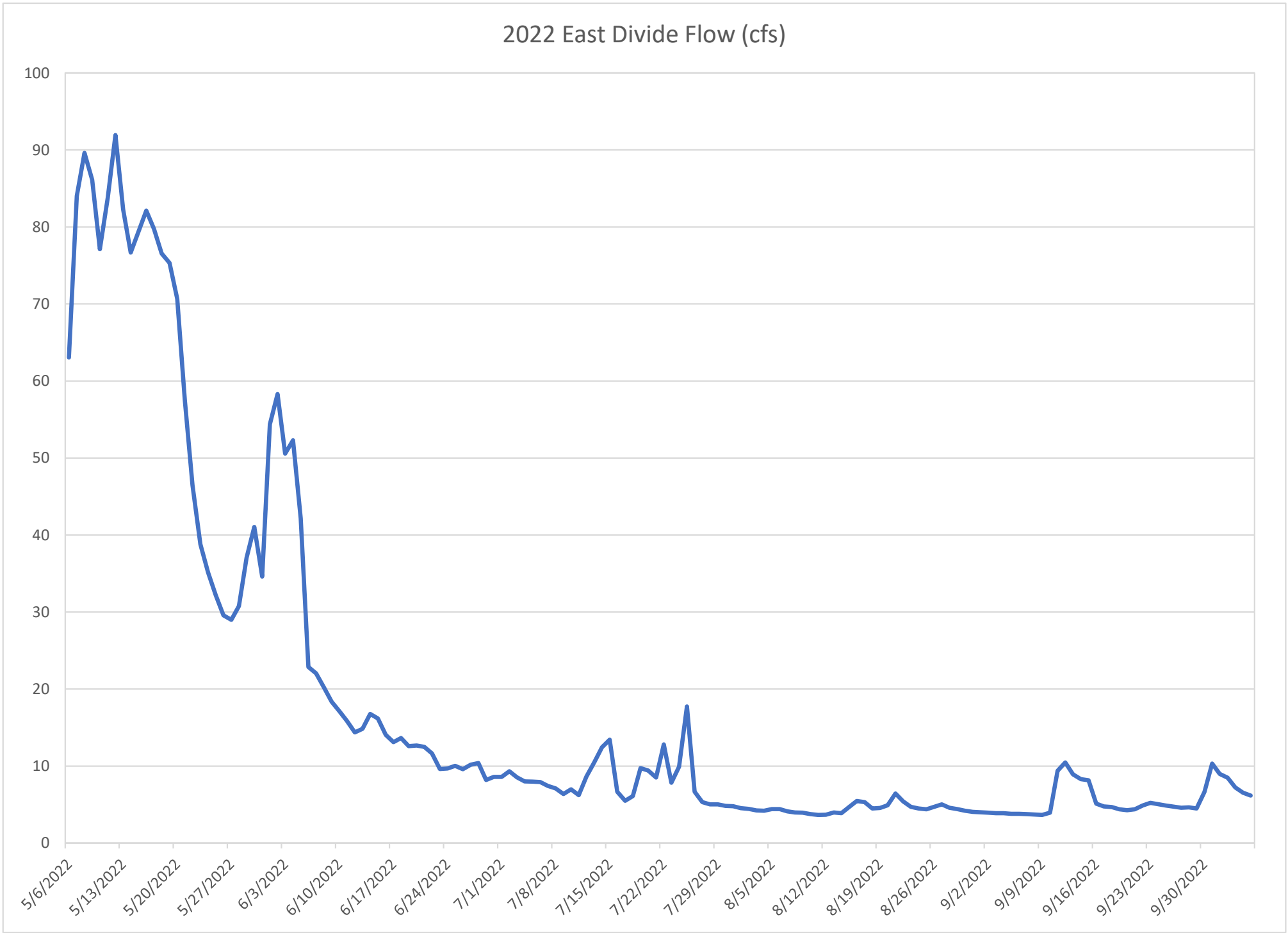

2022 Garfield Flow (cfs)
30
25
20
15
10
5
0
5/7/2022
5/14/2022
5/21/2022
5/28/2022
6/4/2022
6/11/2022
6/18/2022
6/25/2022
7/2/2022
7/9/2022
7/16/2022
7/23/2022
7/30/2022
8/6/2022
8/13/2022
8/20/2022
8/27/2022
9/3/2022

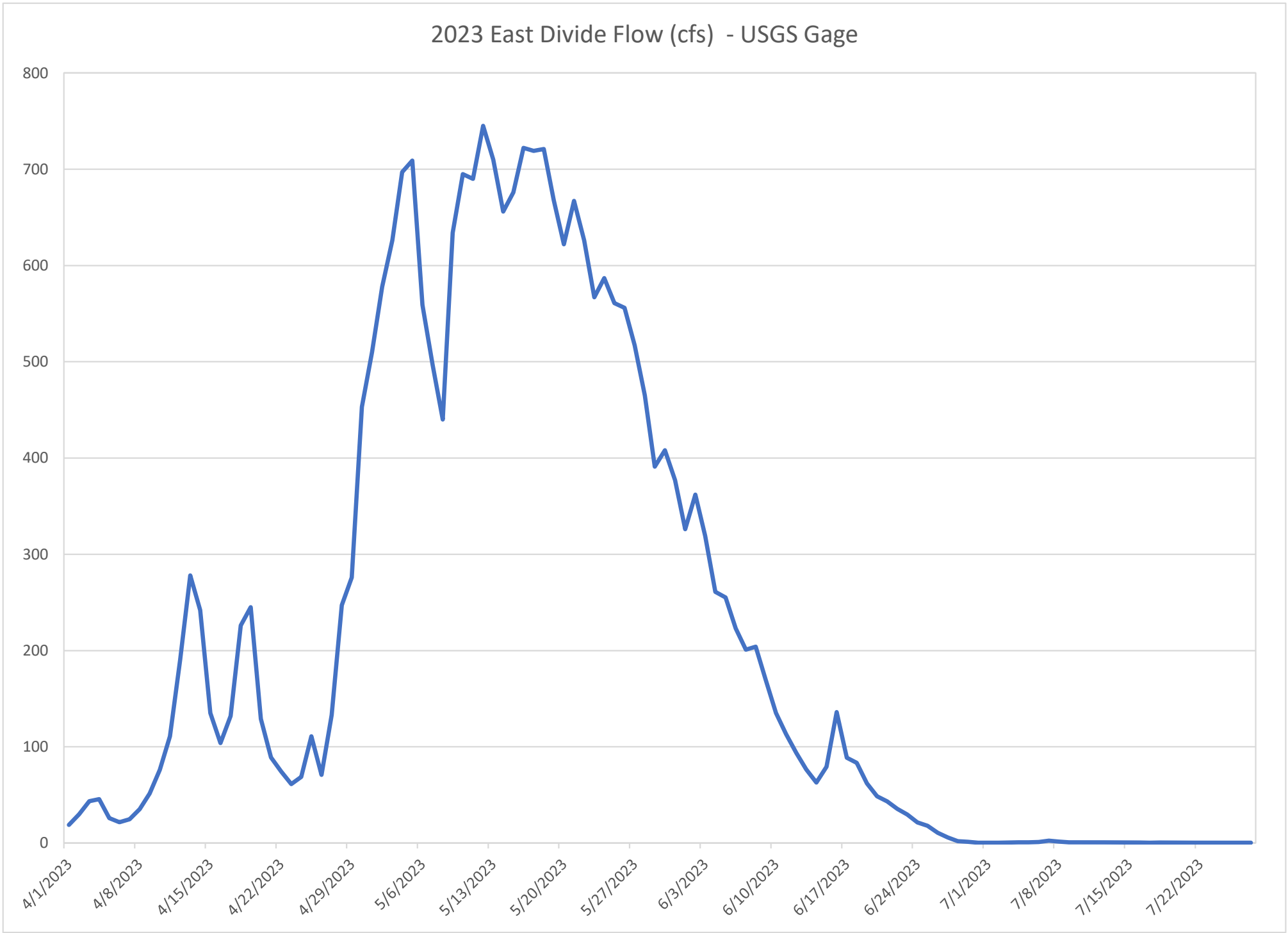

2023 Garfield Flow (cfs)
25
20
15
10
5
0
5/24/2023
5/26/2023
5/28/2023
5/30/2023
6/1/2023
6/3/2023
6/5/2023
6/7/2023
6/9/2023
6/11/2023
6/13/2023
6/15/2023
6/17/2023
6/19/2023
6/21/2023
6/23/2023
6/25/2023
6/27/2023
6/29/2023
7/1/2023
7/3/2023
7/5/2023
7/7/2023
7/9/2023
7/11/2023
7/13/2023
7/15/2023
7/17/2023
7/19/2023
7/21/2023
7/23/2023

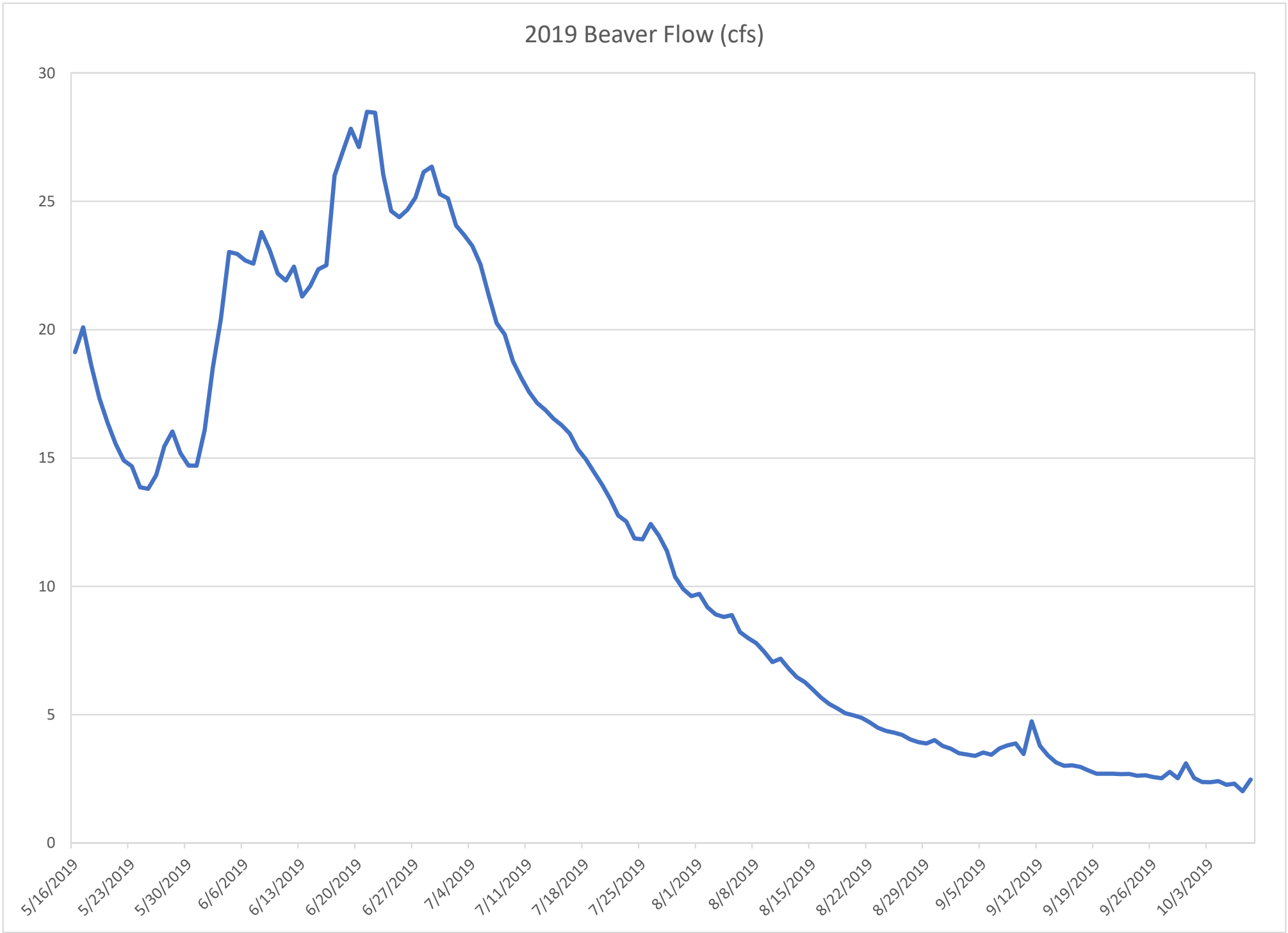

2019 East Divide Flow (cfs)
70
60
50
40
30
20
10
0
6/13/2019
6/20/2019
6/27/2019
7/4/2019
7/11/2019
7/18/2019
7/25/2019
8/1/2019
8/8/2019
8/15/2019
8/22/2019
8/29/2019
9/5/2019
9/12/2019
9/19/2019
9/26/2019
10/3/2019

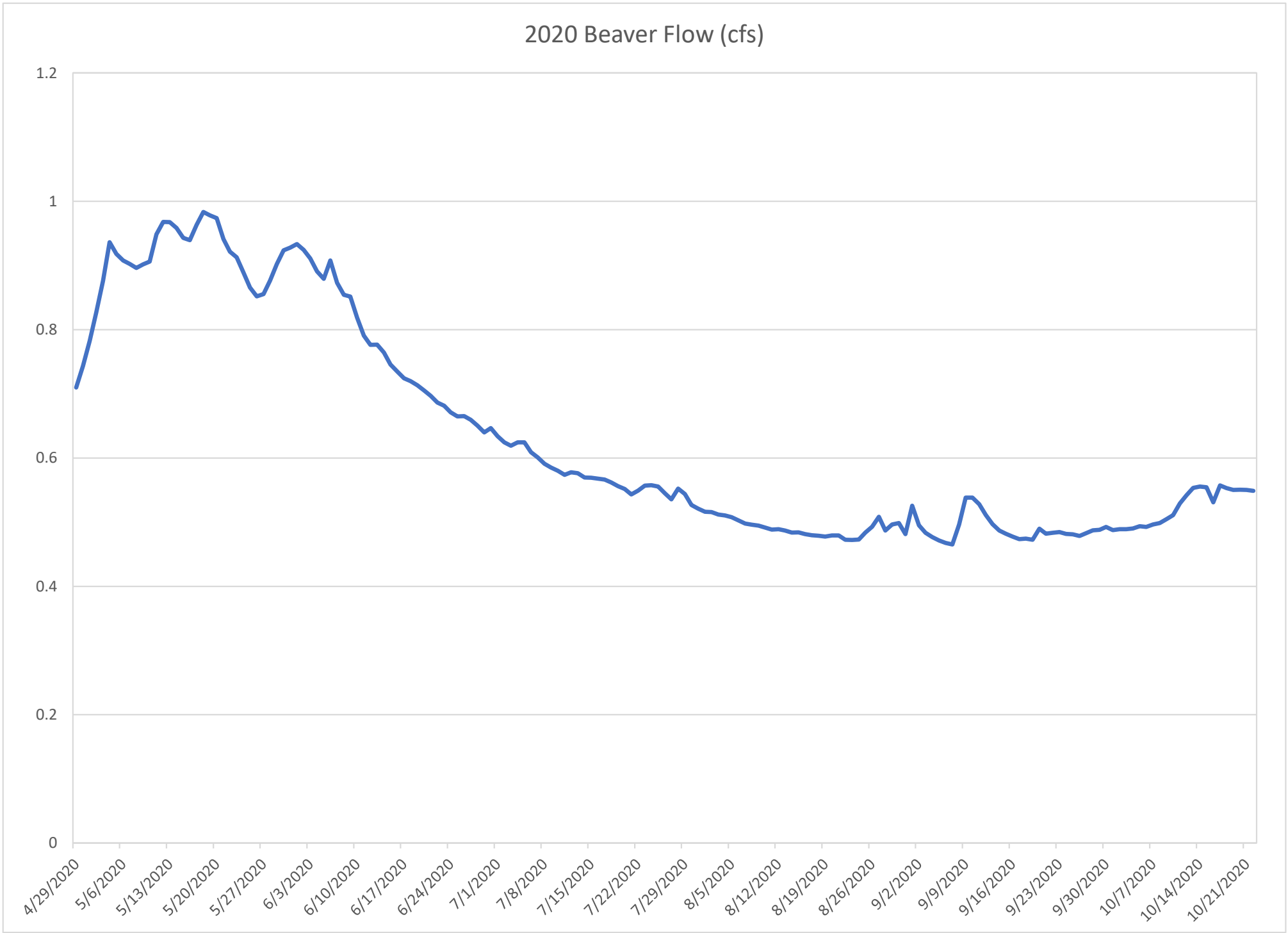

2020 East Divide Flow (cfs)
45
40
35
30
25
20
15
10
5
0
5/1/2020
5/8/2020
5/15/2020
5/22/2020
5/29/2020
6/5/2020
6/12/2020
6/19/2020
6/26/2020
7/3/2020
7/10/2020
7/17/2020
7/24/2020
7/31/2020
8/7/2020
8/14/2020
8/21/2020
8/28/2020
9/4/2020
9/11/2020
9/18/2020
9/25/2020
10/2/2020
10/9/2020
10/16/2020

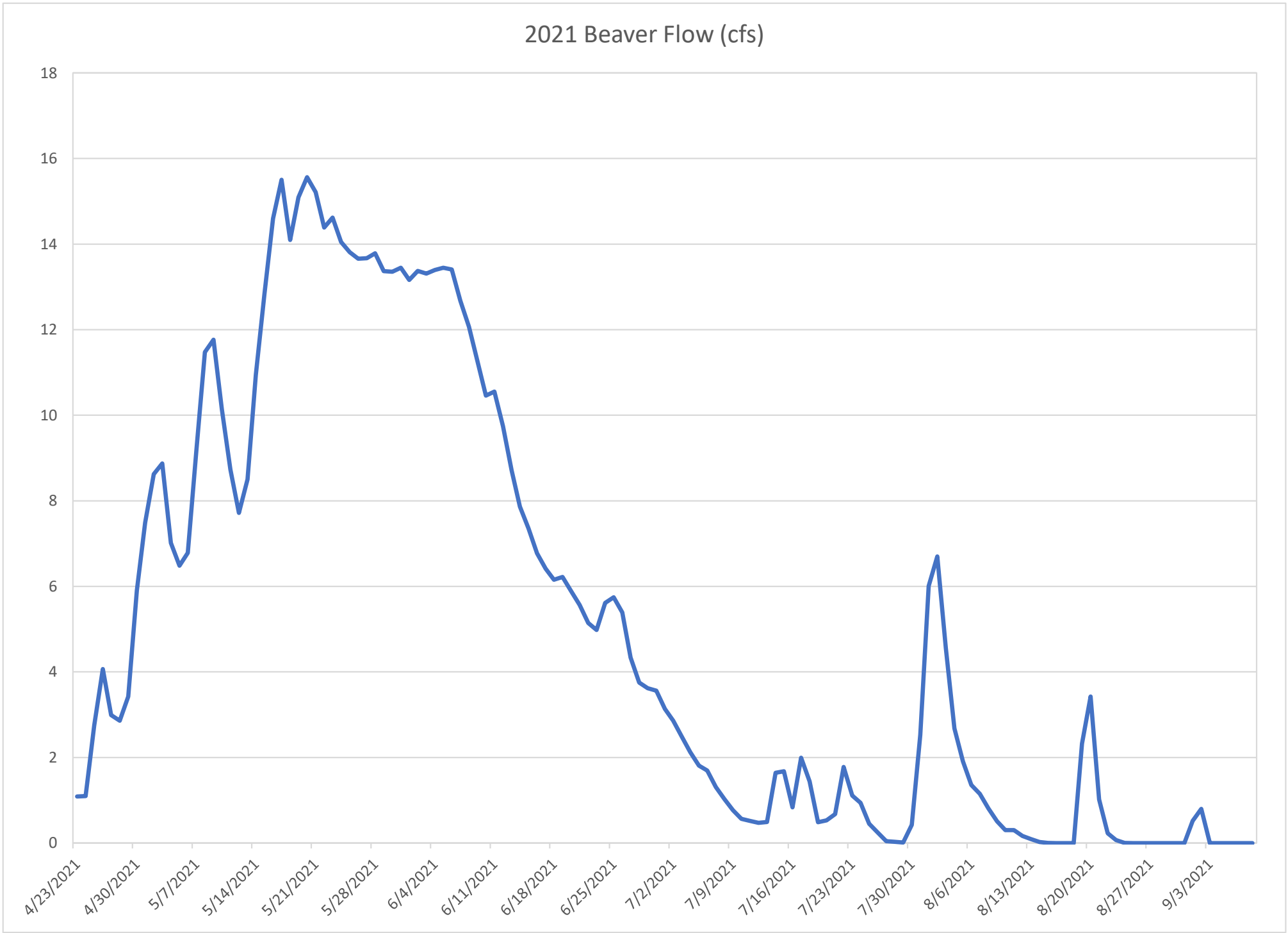

2021 East Divide Flow (cfs)
25
20
15
10
5
0
4/24/2021
5/1/2021
5/8/2021
5/15/2021
5/22/2021
5/29/2021
6/5/2021
6/12/2021
6/19/2021
6/26/2021
7/3/2021
7/10/2021
7/17/2021
7/24/2021
7/31/2021
8/7/2021
8/14/2021
8/21/2021
8/28/2021
9/4/2021

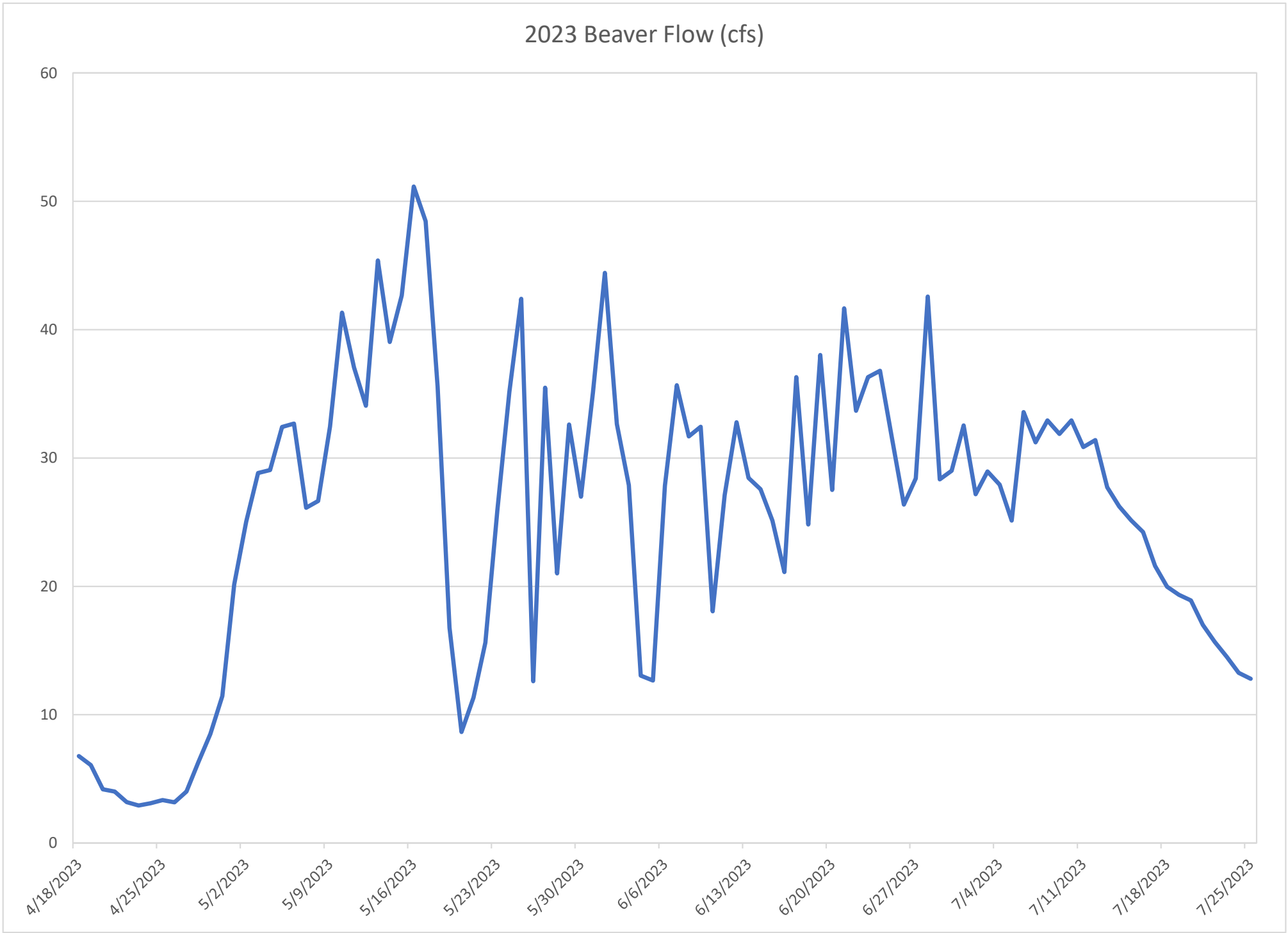

2022 East Divide Flow (cfs)
100
90
80
70
60
50
40
30
20
10
0
5/6/2022
5/13/2022
5/20/2022
5/27/2022
6/3/2022
6/10/2022
6/17/2022
6/24/2022
7/1/2022
7/8/2022
7/15/2022
7/22/2022
7/29/2022
8/5/2022
8/12/2022
8/19/2022
8/26/2022
9/2/2022
9/9/2022
9/16/2022
9/23/2022
9/30/2022

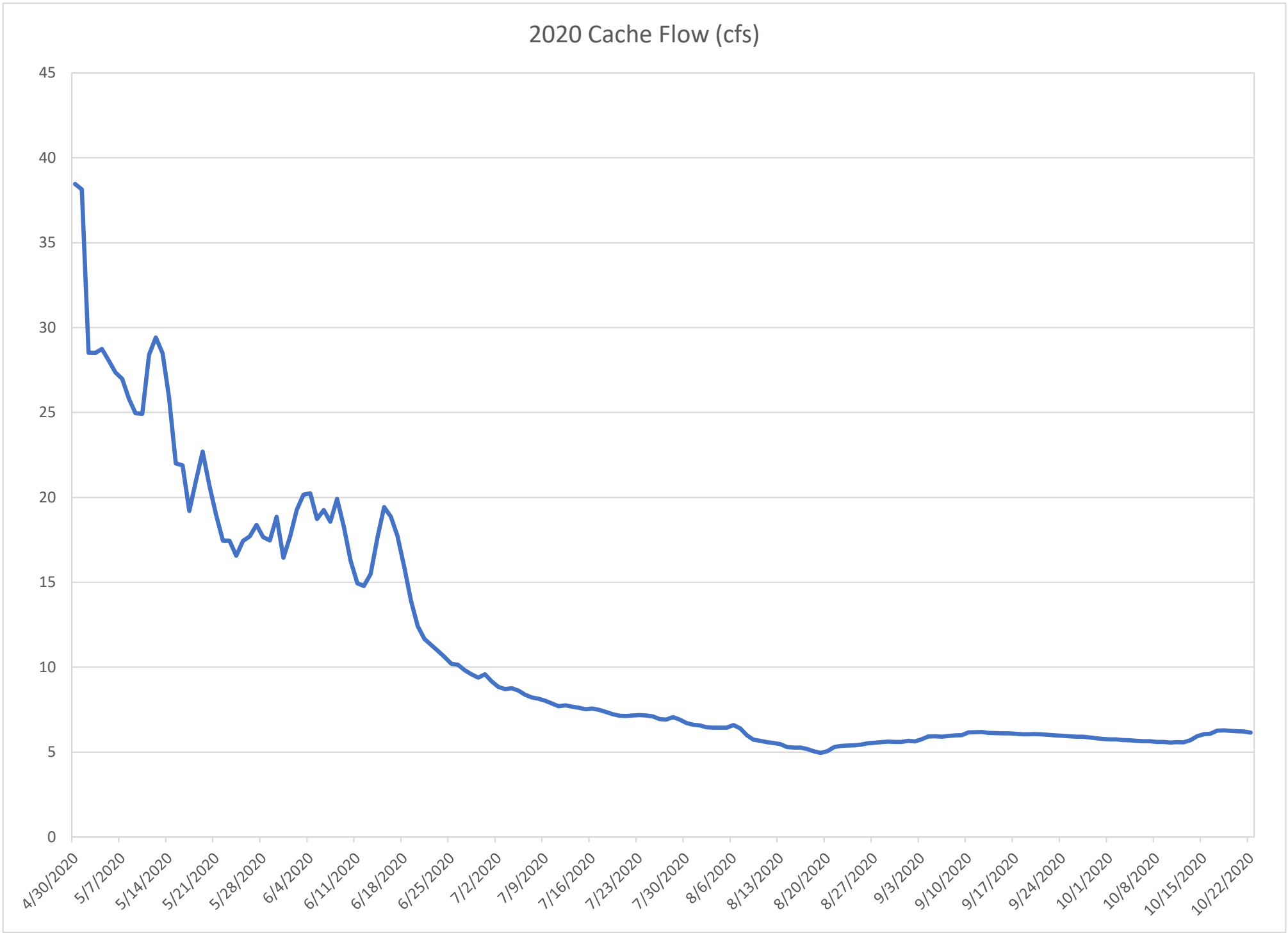

2023 East Divide Flow (cfs) - USGS Gage
800
700
600
500
400
300
200
100
0
4/1/2023
4/8/2023
4/15/2023
4/22/2023
4/29/2023
5/6/2023
5/13/2023
5/20/2023
5/27/2023
6/3/2023
6/10/2023
6/17/2023
6/24/2023
7/1/2023
7/8/2023
7/15/2023
7/22/2023

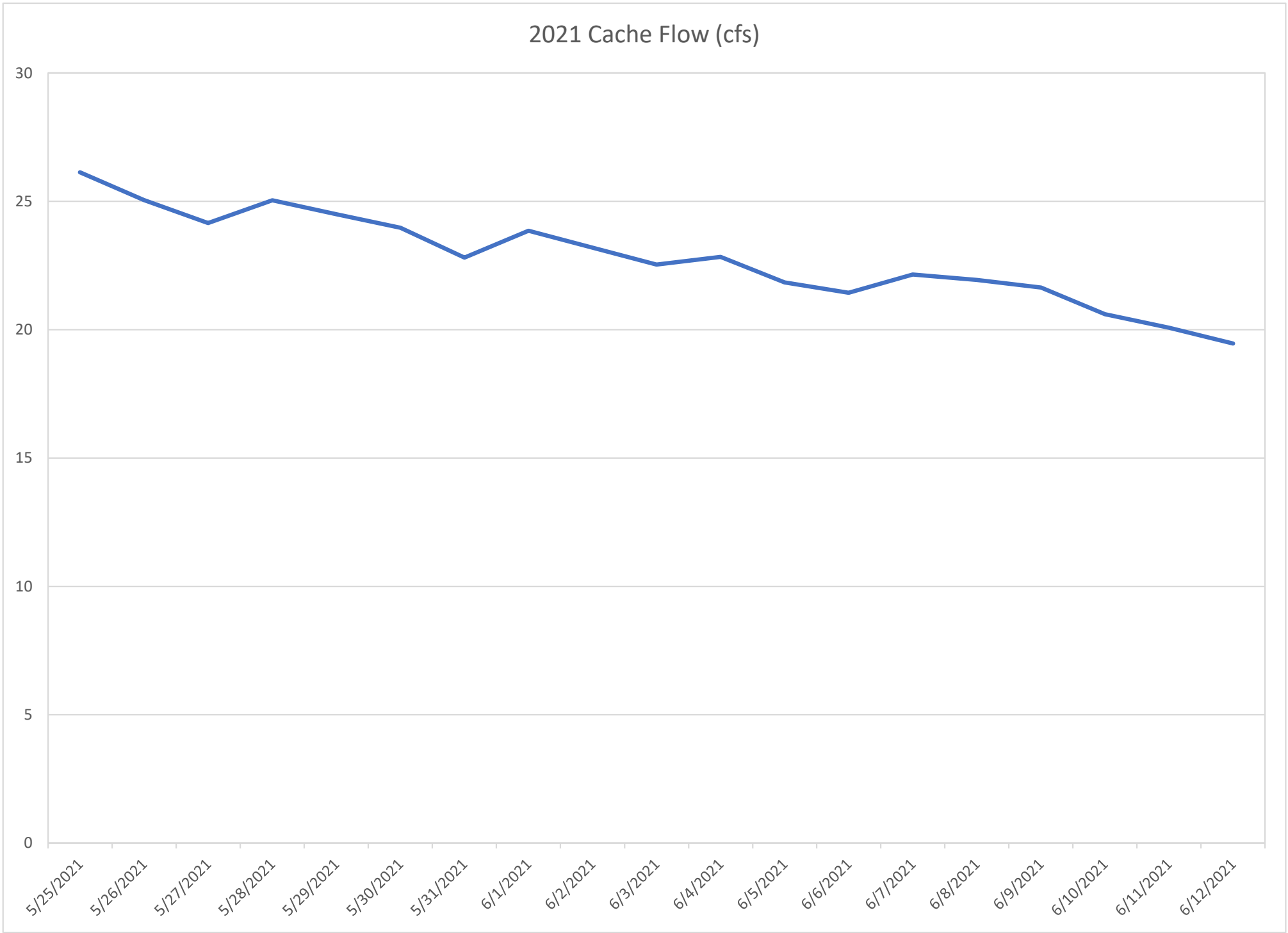

2019 Beaver Flow (cfs)
30
25
20
15
10
5
0
5/16/2019
5/23/2019
5/30/2019
6/6/2019
6/13/2019
6/20/2019
6/27/2019
7/4/2019
7/11/2019
7/18/2019
7/25/2019
8/1/2019
8/8/2019
8/15/2019
8/22/2019
8/29/2019
9/5/2019
9/12/2019
9/19/2019
9/26/2019
10/3/2019

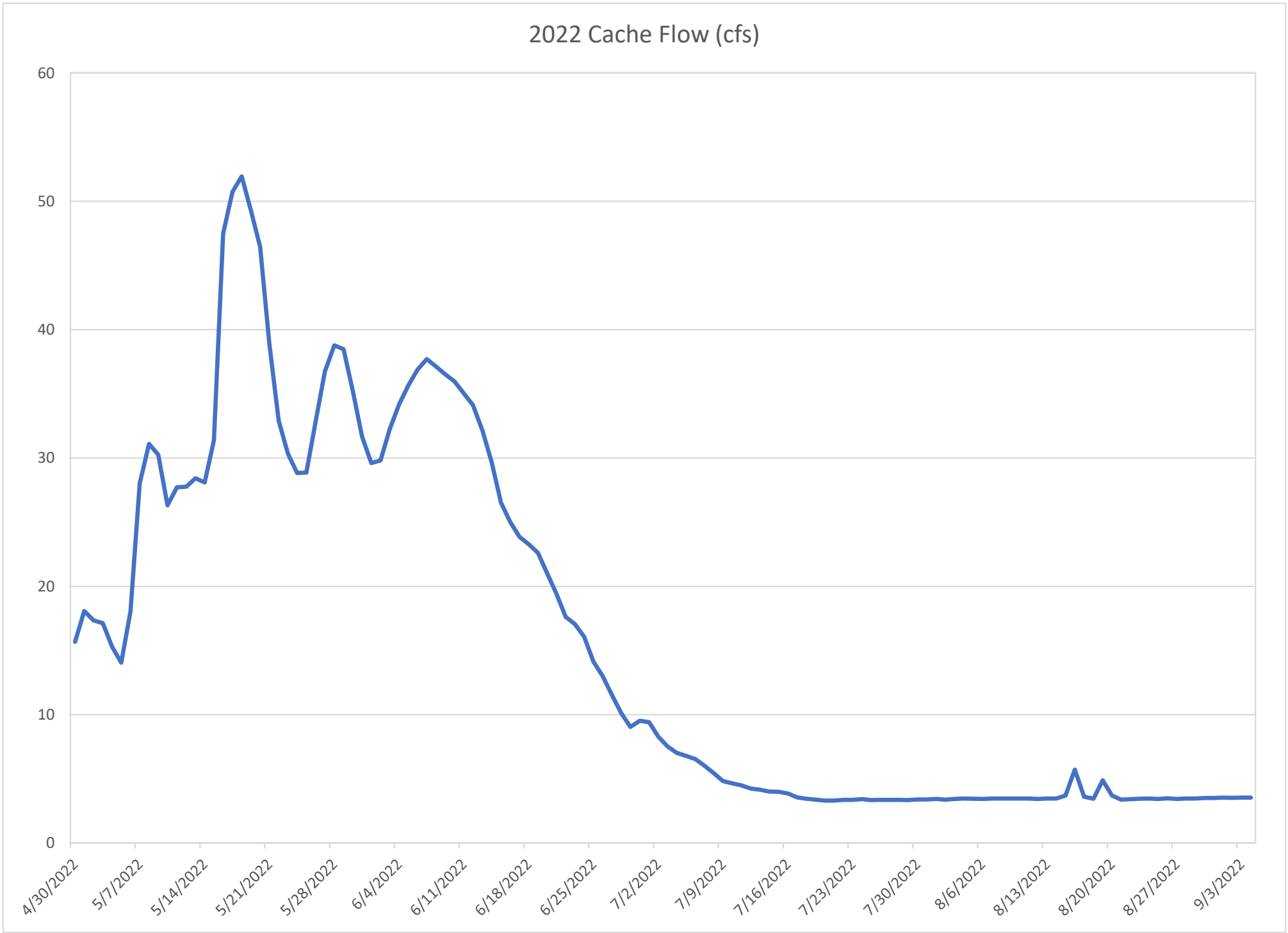

2020 Beaver Flow (cfs)
1.2
1
0.8
0.6
0.4
0.2
0
4/29/2020
5/6/2020
5/13/2020
5/20/2020
5/27/2020
6/3/2020
6/10/2020
6/17/2020
6/24/2020
7/1/2020
7/8/2020
7/15/2020
7/22/2020
7/29/2020
8/5/2020
8/12/2020
8/19/2020
8/26/2020
9/2/2020
9/9/2020
9/16/2020
9/23/2020
9/30/2020
10/7/2020
10/14/2020
10/21/2020

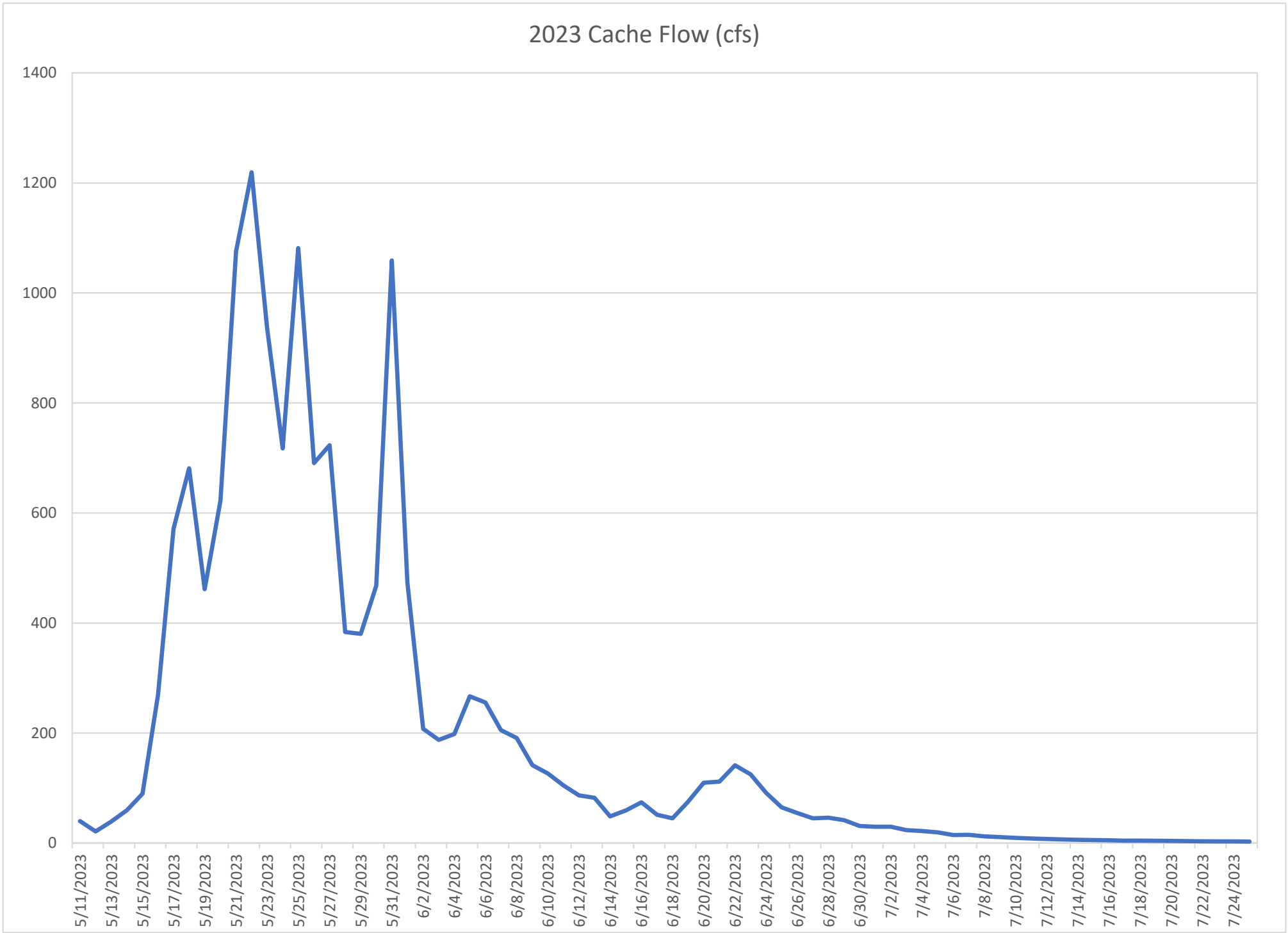

2021 Beaver Flow (cfs)
18
16
14
12
10
8
6
4
2
0
4/23/2021
4/30/2021
5/7/2021
5/14/2021
5/21/2021
5/28/2021
6/4/2021
6/11/2021
6/18/2021
6/25/2021
7/2/2021
7/9/2021
7/16/2021
7/23/2021
7/30/2021
8/6/2021
8/13/2021
8/20/2021
8/27/2021
9/3/2021

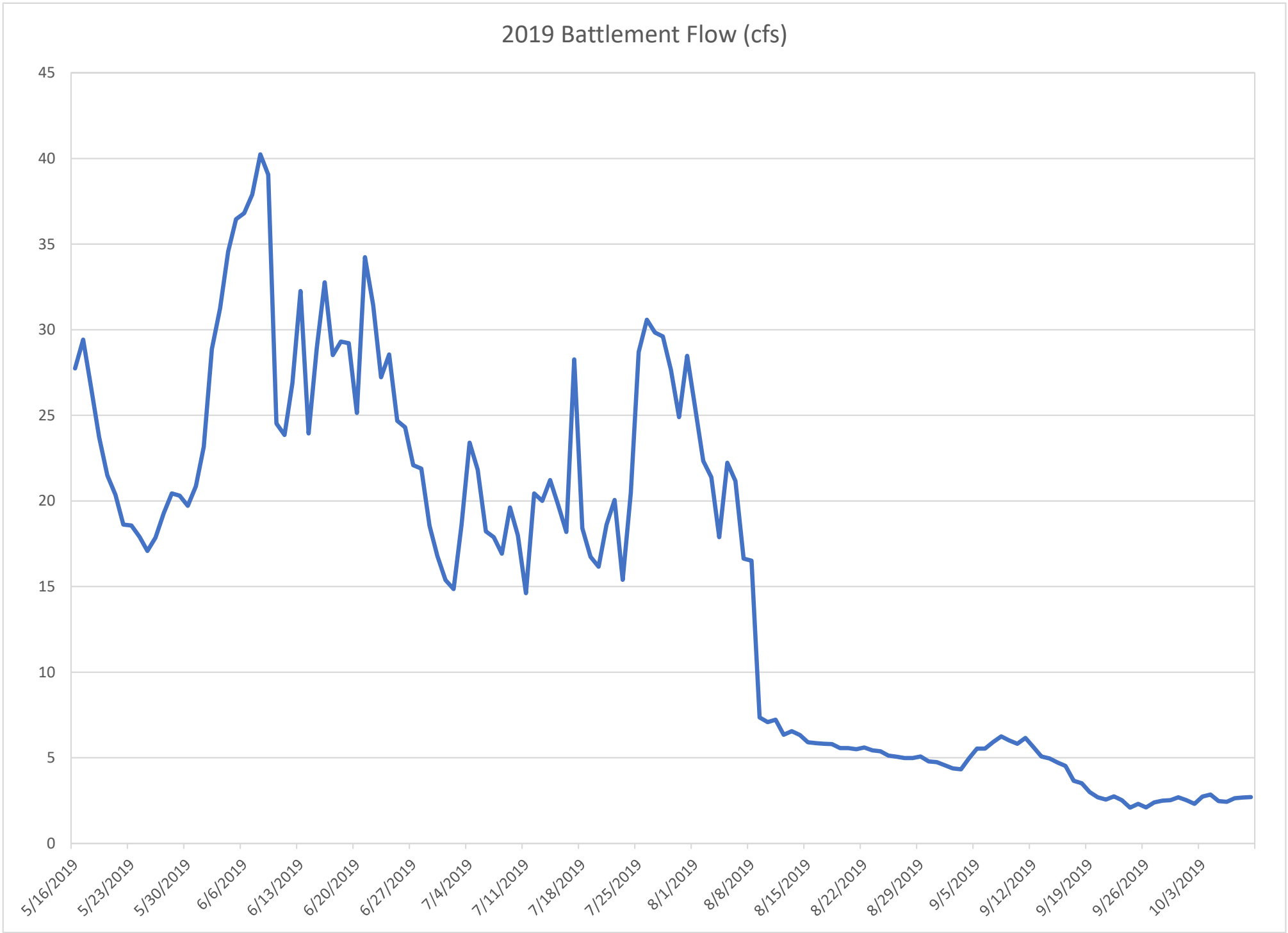

2023 Beaver Flow (cfs)
60
50
40
30
20
10
0
4/18/2023
4/25/2023
5/2/2023
5/9/2023
5/16/2023
5/23/2023
5/30/2023
6/6/2023
6/13/2023
6/20/2023
6/27/2023
7/4/2023
7/11/2023
7/18/2023
7/25/2023

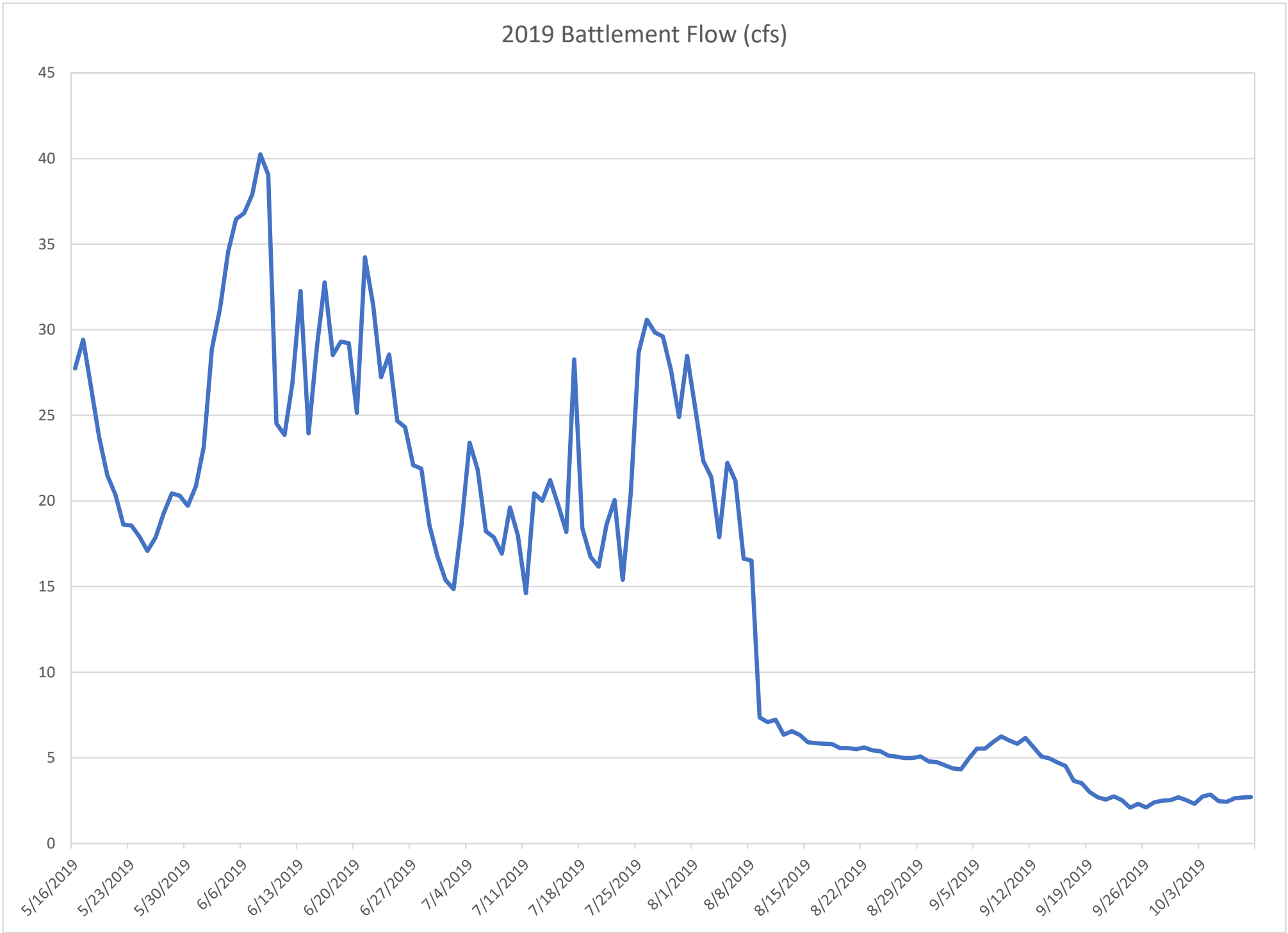

2020 Cache Flow (cfs)
45
40
35
30
25
20
15
10
5
0
4/30/2020
5/7/2020
5/14/2020
5/21/2020
5/28/2020
6/4/2020
6/11/2020
6/18/2020
6/25/2020
7/2/2020
7/9/2020
7/16/2020
7/23/2020
7/30/2020
8/6/2020
8/13/2020
8/20/2020
8/27/2020
9/3/2020
9/10/2020
9/17/2020
9/24/2020
10/1/2020
10/8/2020
10/15/2020
10/22/2020


2021 Cache Flow (cfs)
30
25
20
15
10
5
0
5/25/2021
5/26/2021
5/27/2021
5/28/2021
5/29/2021
5/30/2021
5/31/2021
6/1/2021
6/2/2021
6/3/2021
6/4/2021
6/5/2021
6/6/2021
6/7/2021
6/8/2021
6/9/2021
6/10/2021
6/11/2021
6/12/2021


2022 Cache Flow (cfs)
60
50
40
30
20
10
0
4/30/2022
5/7/2022
5/14/2022
5/21/2022
5/28/2022
6/4/2022
6/11/2022
6/18/2022
6/25/2022
7/2/2022
7/9/2022
7/16/2022
7/23/2022
7/30/2022
8/6/2022
8/13/2022
8/20/2022
8/27/2022
9/3/2022


2023 Cache Flow (cfs)
1400
1200
1000
800
600
400
200
0
5/11/2023
5/13/2023
5/15/2023
5/17/2023
5/19/2023
5/21/2023
5/23/2023
5/25/2023
5/27/2023
5/29/2023
5/31/2023
6/2/2023
6/4/2023
6/6/2023
6/8/2023
6/10/2023
6/12/2023
6/14/2023
6/16/2023
6/18/2023
6/20/2023
6/22/2023
6/24/2023
6/26/2023
6/28/2023
6/30/2023
7/2/2023
7/4/2023
7/6/2023
7/8/2023
7/10/2023
7/12/2023
7/14/2023
7/16/2023
7/18/2023
7/20/2023
7/22/2023
7/24/2023


2019 Battlement Flow (cfs)
45
40
35
30
25
20
15
10
5
0
5/16/2019
5/23/2019
5/30/2019
6/6/2019
6/13/2019
6/20/2019
6/27/2019
7/4/2019
7/11/2019
7/18/2019
7/25/2019
8/1/2019
8/8/2019
8/15/2019
8/22/2019
8/29/2019
9/5/2019
9/12/2019
9/19/2019
9/26/2019
10/3/2019


2019 Battlement Flow (cfs)
45
40
35
30
25
20
15
10
5
0
5/16/2019
5/23/2019
5/30/2019
6/6/2019
6/13/2019
6/20/2019
6/27/2019
7/4/2019
7/11/2019
7/18/2019
7/25/2019
8/1/2019
8/8/2019
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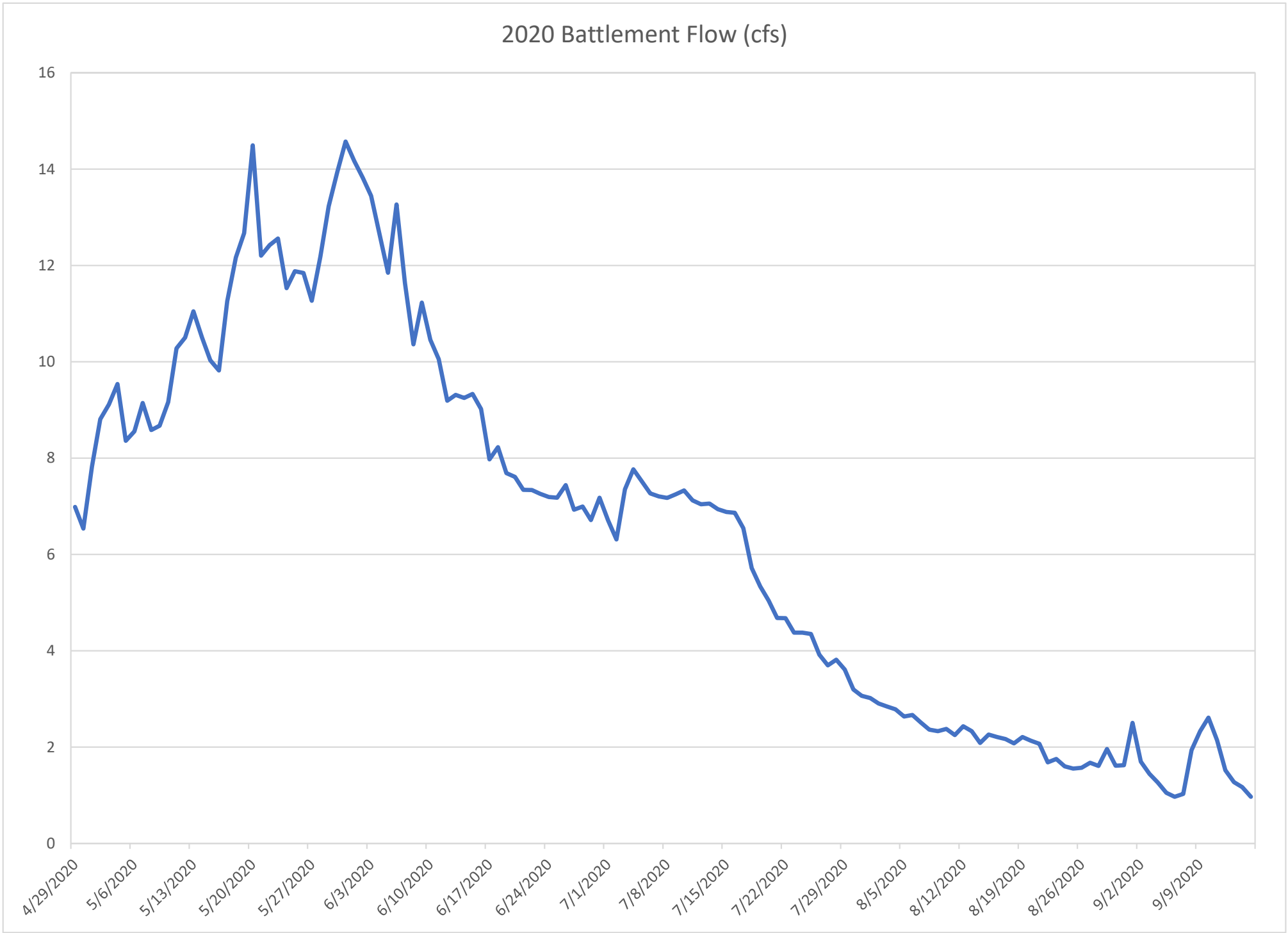
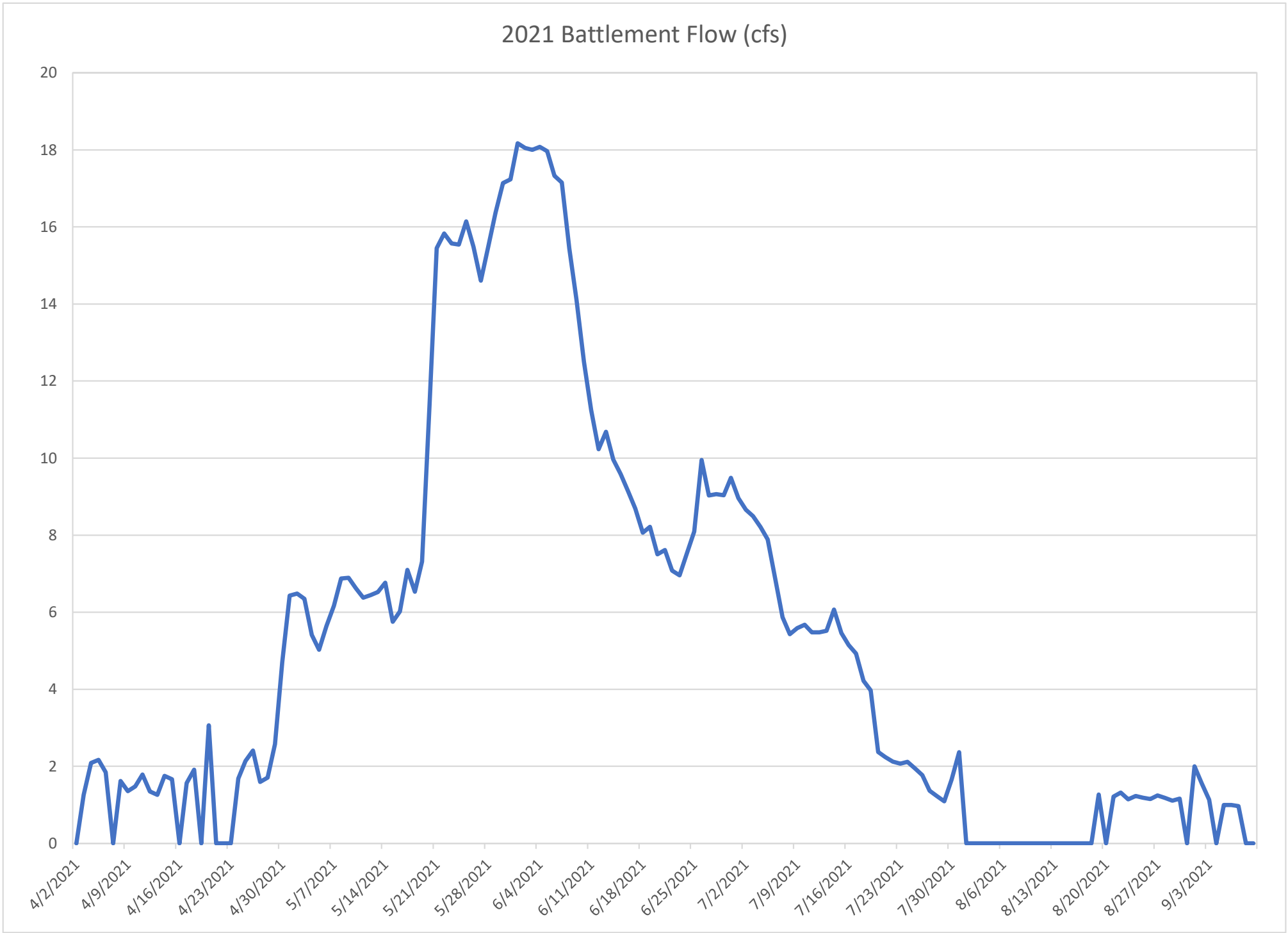
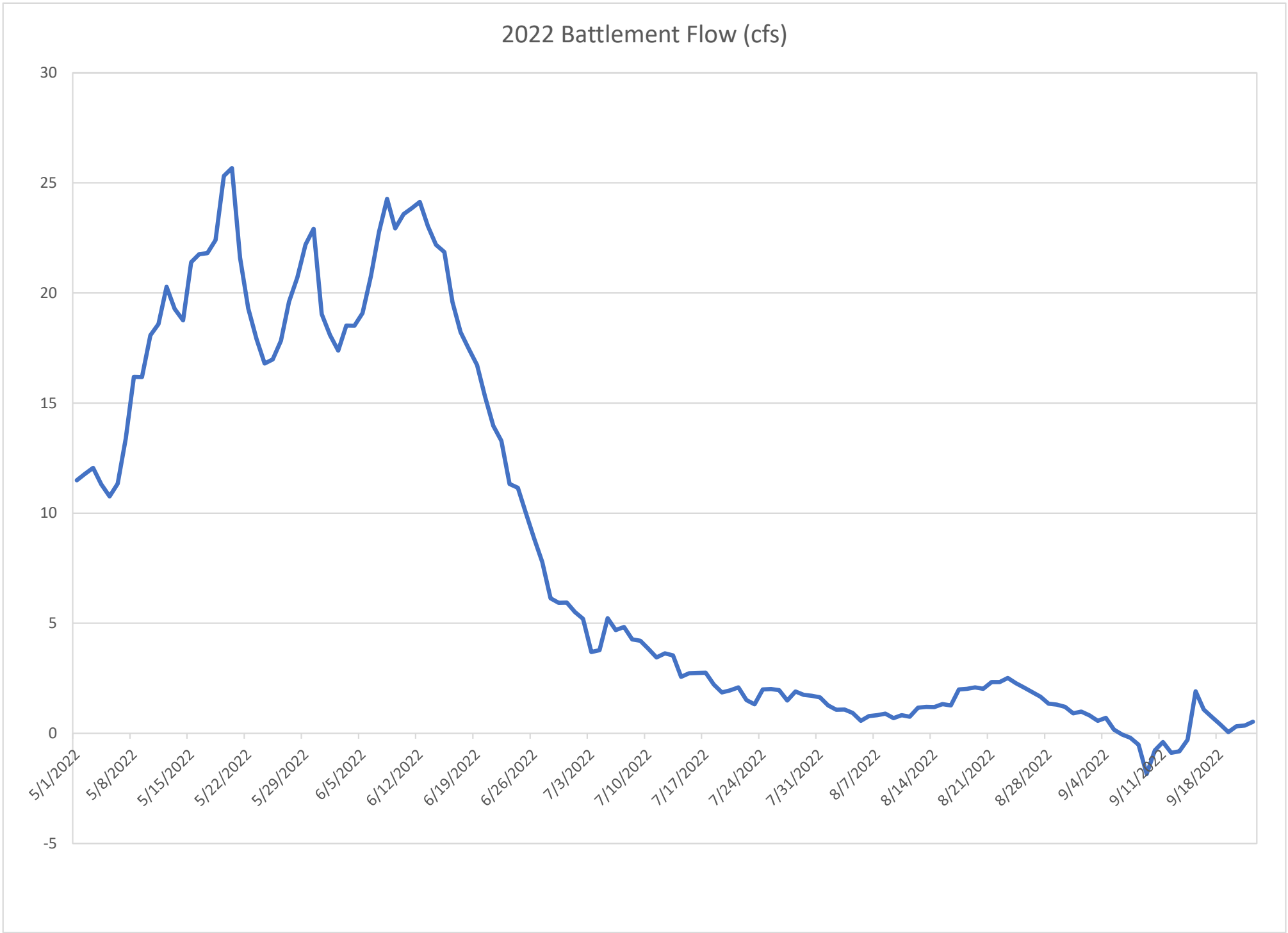
8/29/2019
9/5/2019
9/12/2019
9/19/2019
9/26/2019
10/3/2019

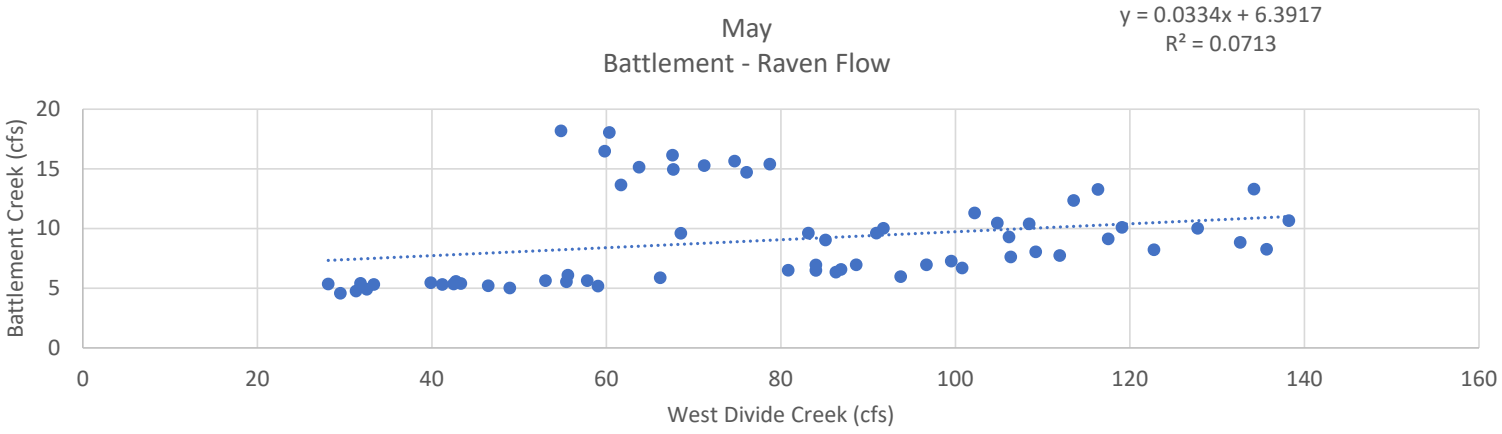

2020 Battlement Flow (cfs)
16
14
12
10
8
6
4
2
0
4/29/2020
5/6/2020
5/13/2020
5/20/2020
5/27/2020
6/3/2020
6/10/2020
6/17/2020
6/24/2020
7/1/2020
7/8/2020
7/15/2020
7/22/2020
7/29/2020
8/5/2020
8/12/2020
8/19/2020
8/26/2020
9/2/2020
9/9/2020

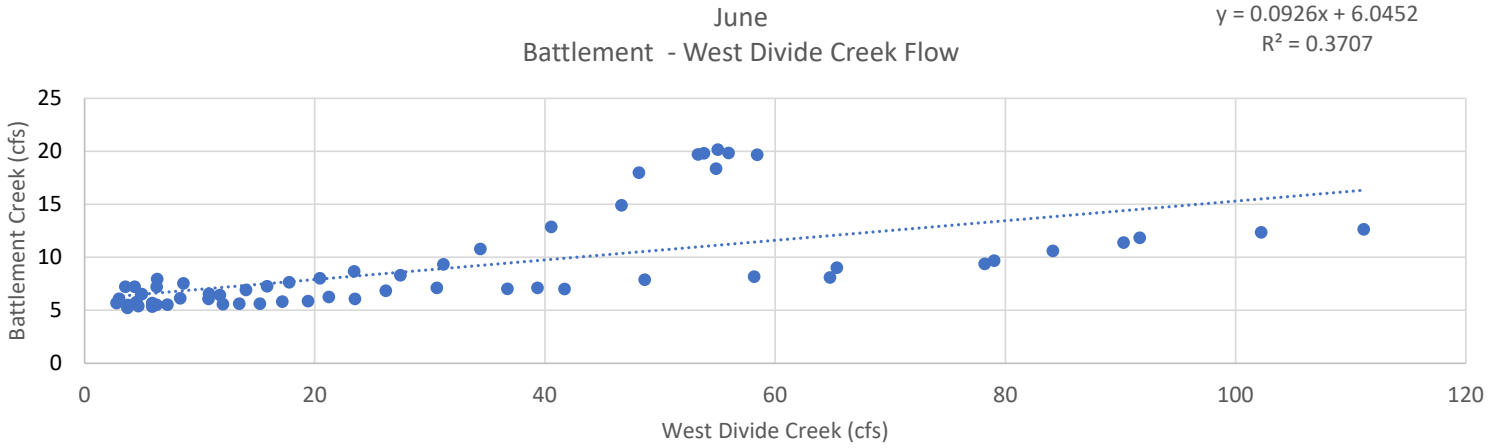

2021 Battlement Flow (cfs)
20
18
16
14
12
10
8
6
4
2
0
4/2/2021
4/9/2021
4/16/2021
4/23/2021
4/30/2021
5/7/2021
5/14/2021
5/21/2021
5/28/2021
6/4/2021
6/11/2021
6/18/2021
6/25/2021
7/2/2021
7/9/2021
7/16/2021
7/23/2021
7/30/2021
8/6/2021
8/13/2021
8/20/2021
8/27/2021
9/3/2021

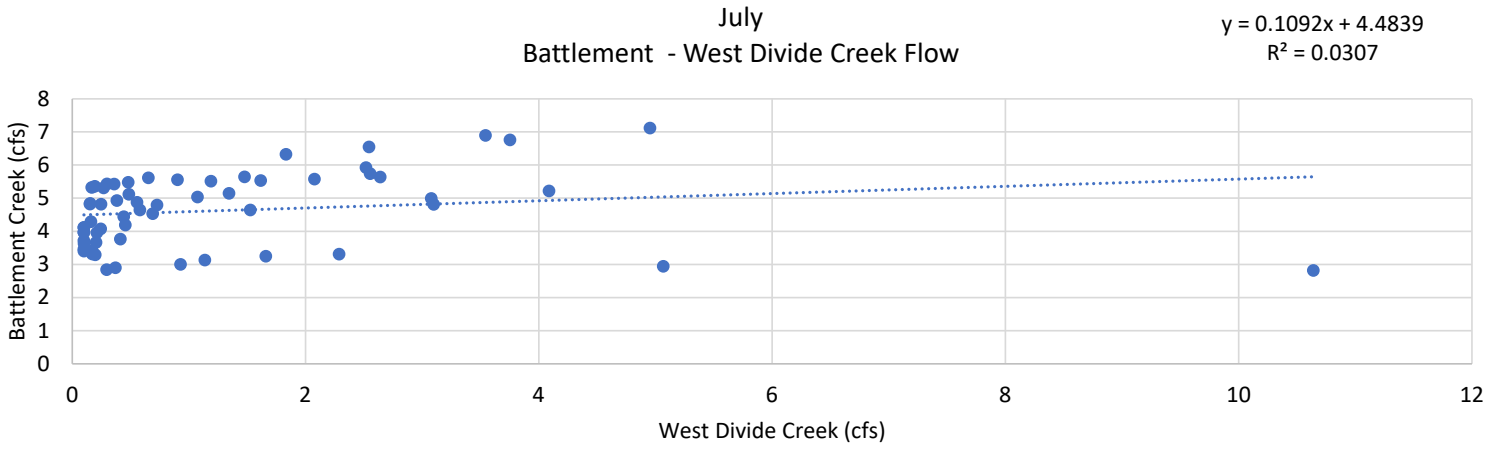

2022 Battlement Flow (cfs)
30
25
20
15
10
5
0
-5
5/1/2022
5/8/2022
5/15/2022
5/22/2022
5/29/2022
6/5/2022
6/12/2022
6/19/2022
6/26/2022
7/3/2022
7/10/2022
7/17/2022
7/24/2022
7/31/2022
8/7/2022
8/14/2022
8/21/2022
8/28/2022
9/4/2022
9/11/2022
9/18/2022

Appendix B: Correlations to West Divide Creek Raven Gage

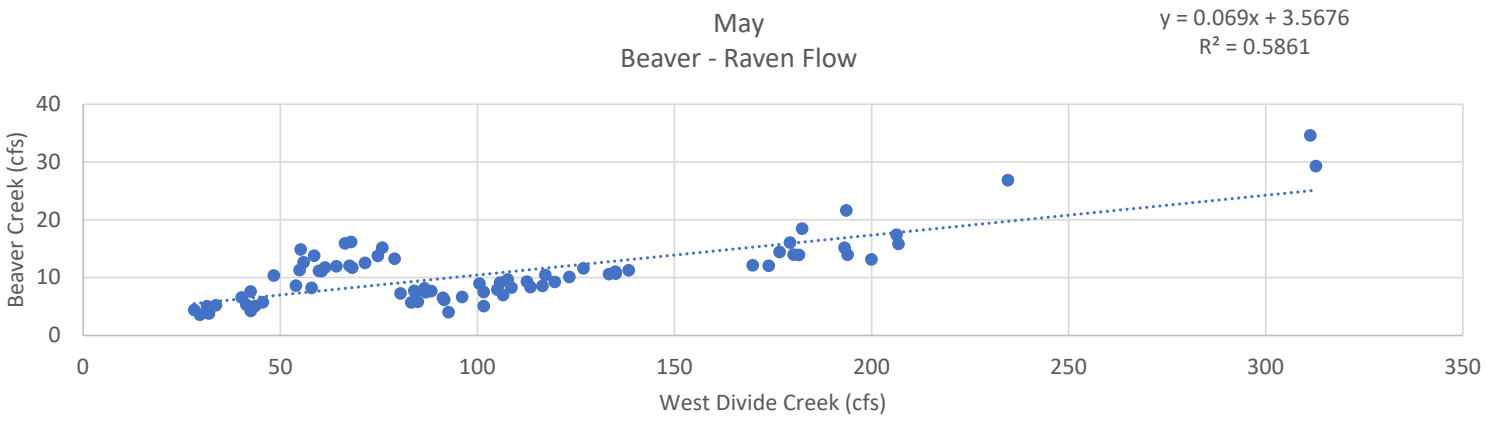
Battlement Creek

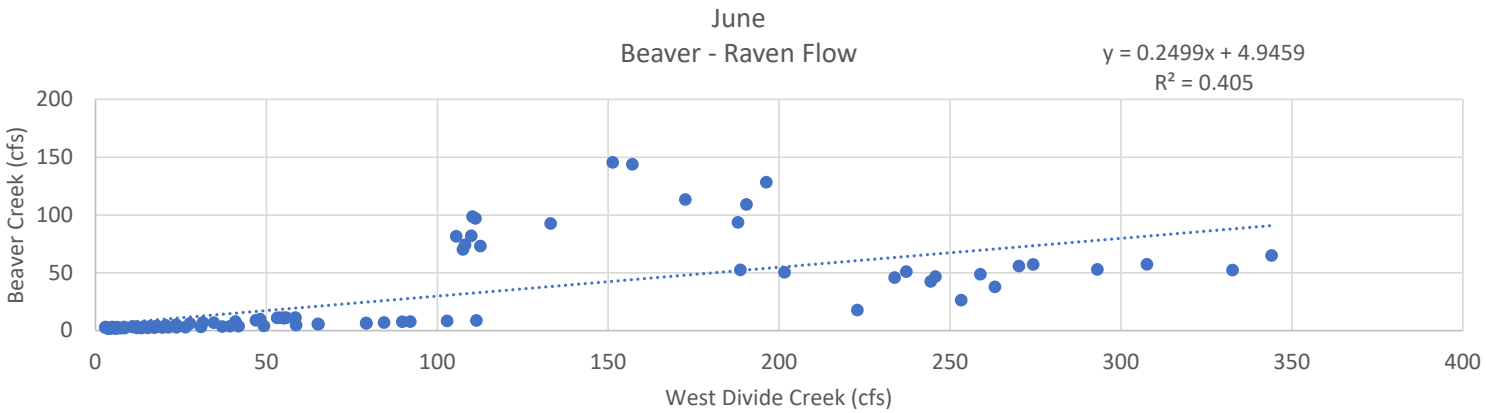


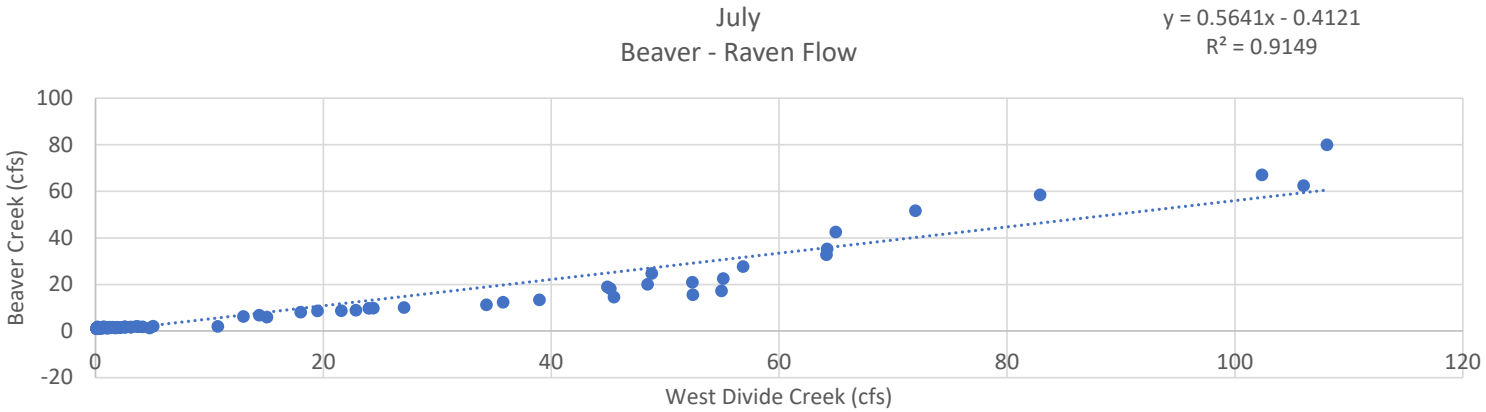




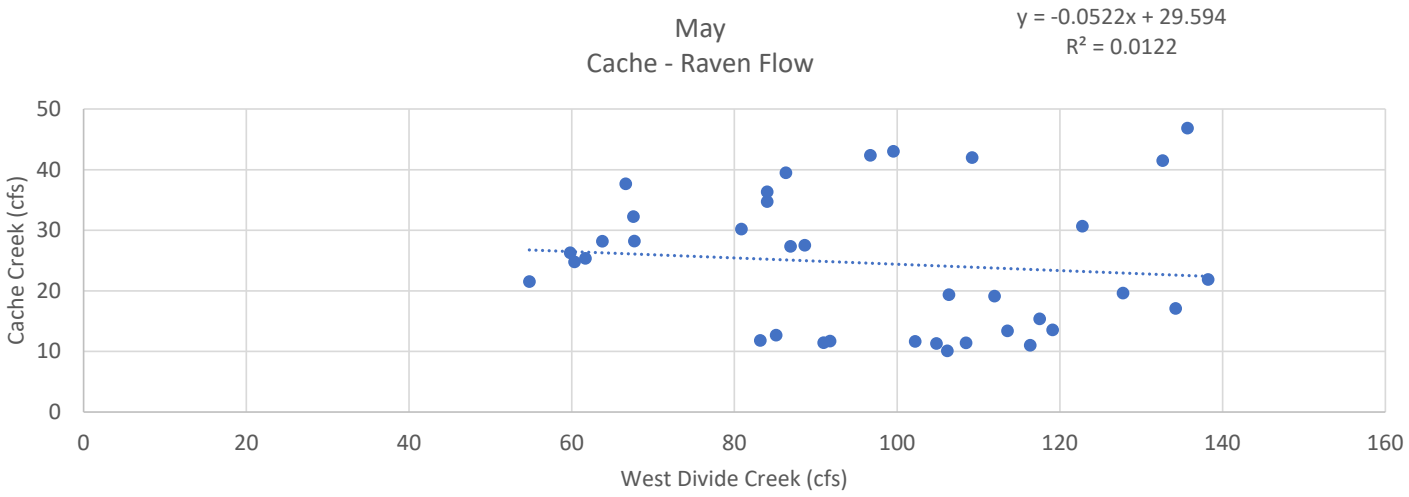
Beaver Creek

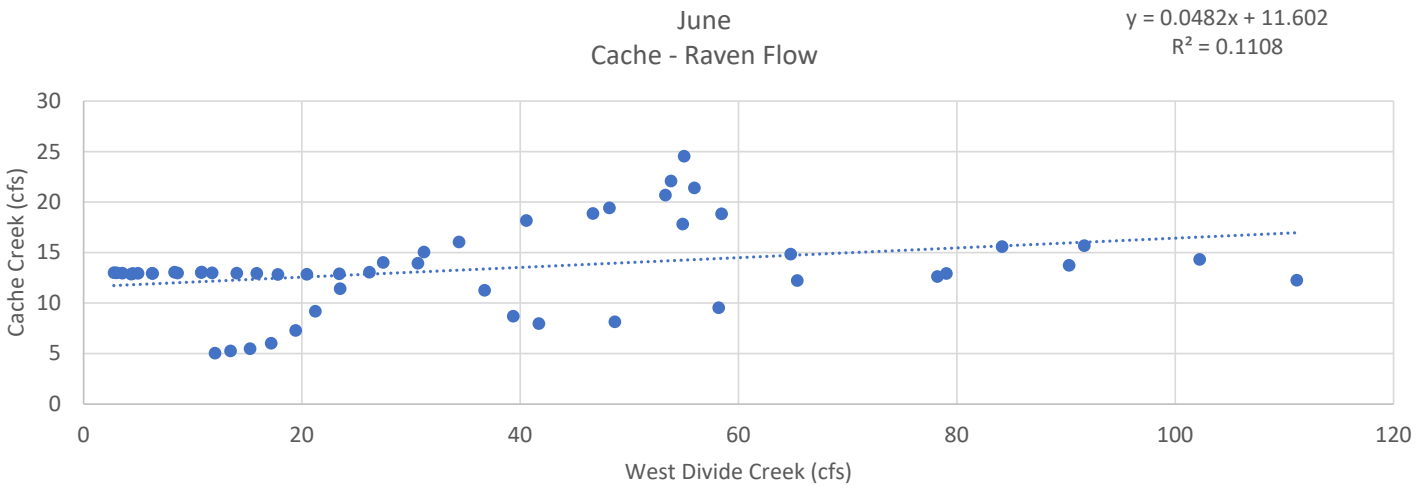


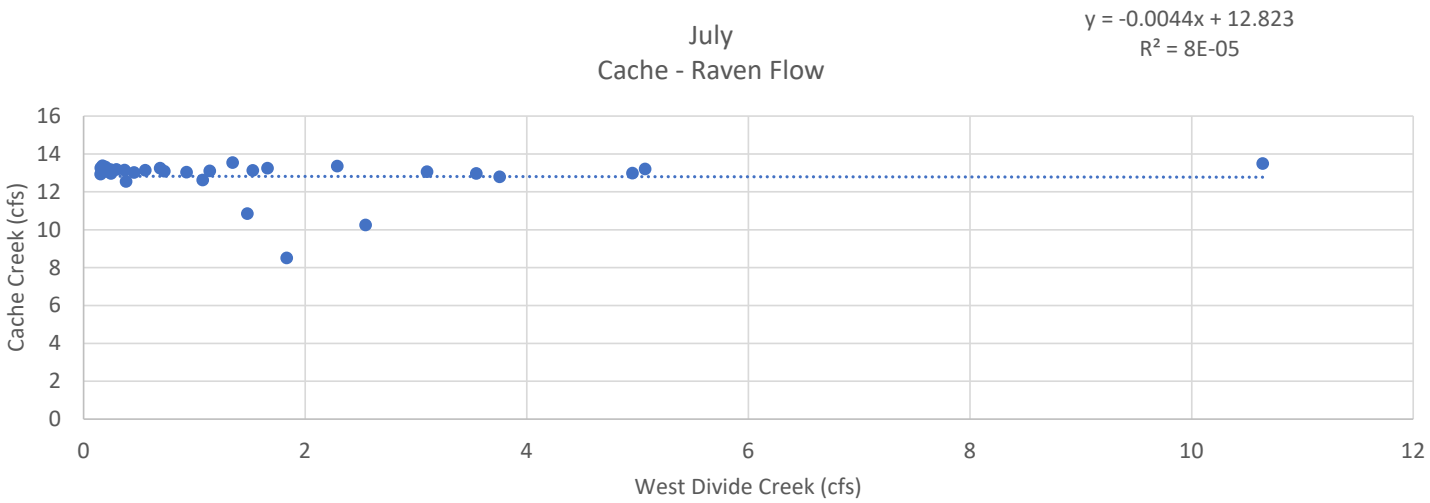




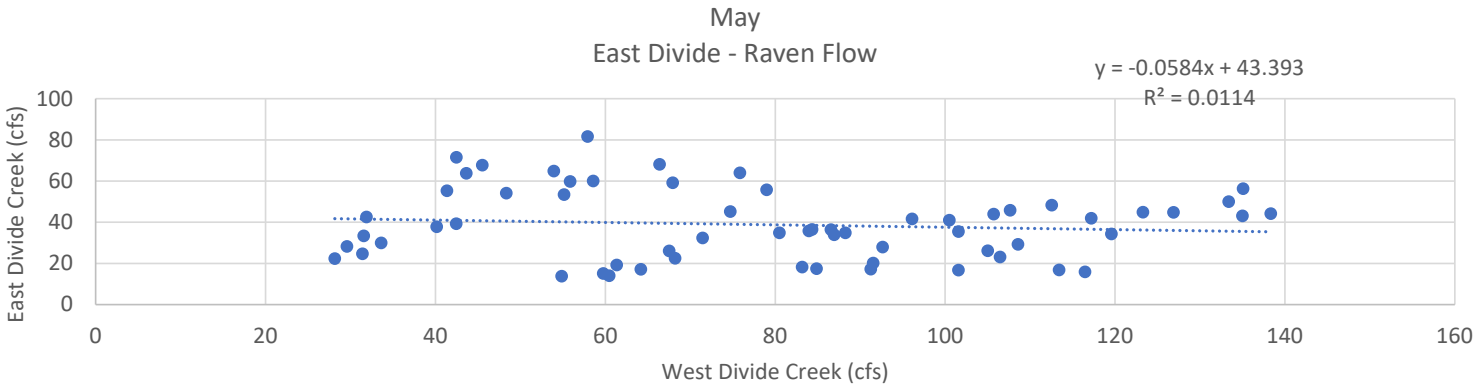
Cache Creek

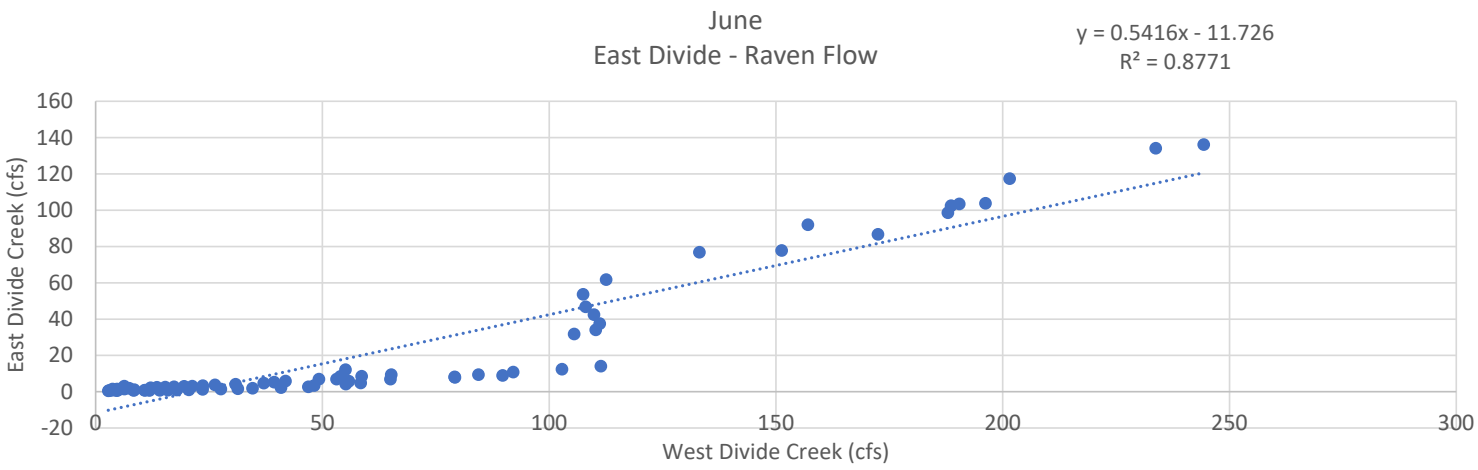

May
Cache - Raven Flow
y = -0.0522x + 29.594
R² = 0.0122
Cache Creek (cfs)
West Divide Creek (cfs)
0
10
20
30
40
50
0
20
40
60
80
100
120
140
160

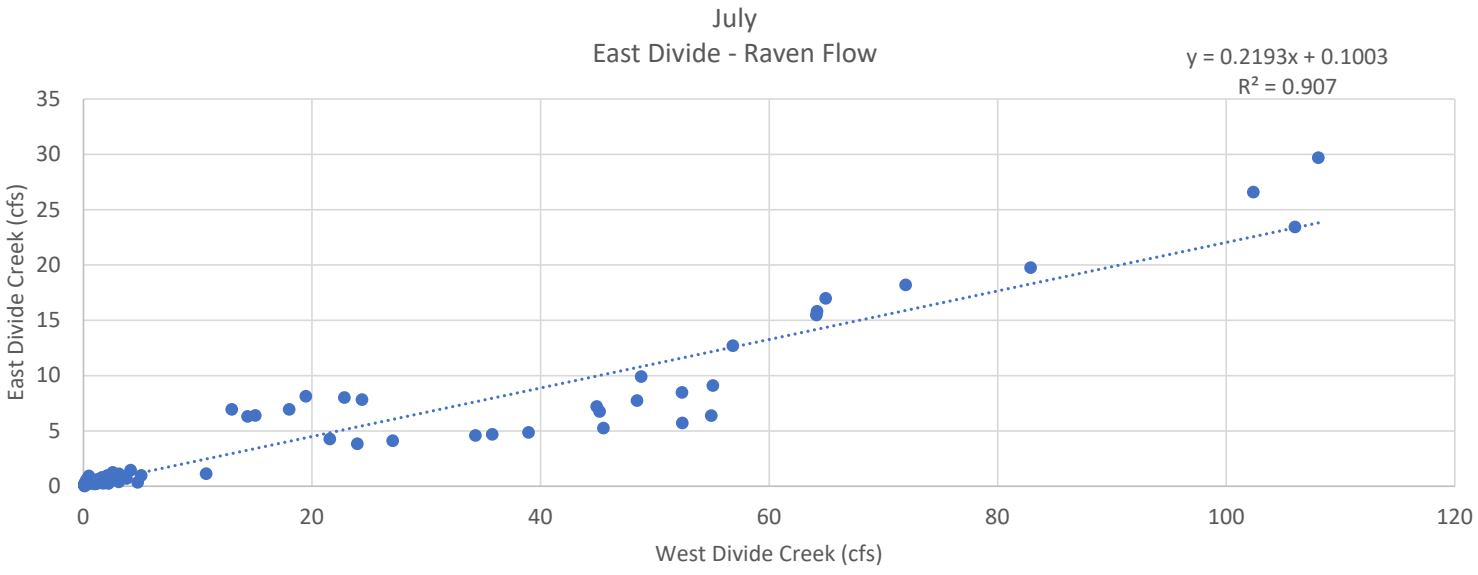

June
Cache - Raven Flow
y = 0.0482x + 11.602
R² = 0.1108
Cache Creek (cfs)
West Divide Creek (cfs)
0
5
10
15
20
25
30
0
20
40
60
80
100
120


July
Cache - Raven Flow
y = -0.0044x + 12.823
R² = 8E-05
Cache Creek (cfs)
West Divide Creek (cfs)
0
2
4
6
8
10
12
14
16
0
2
4
6
8
10
12

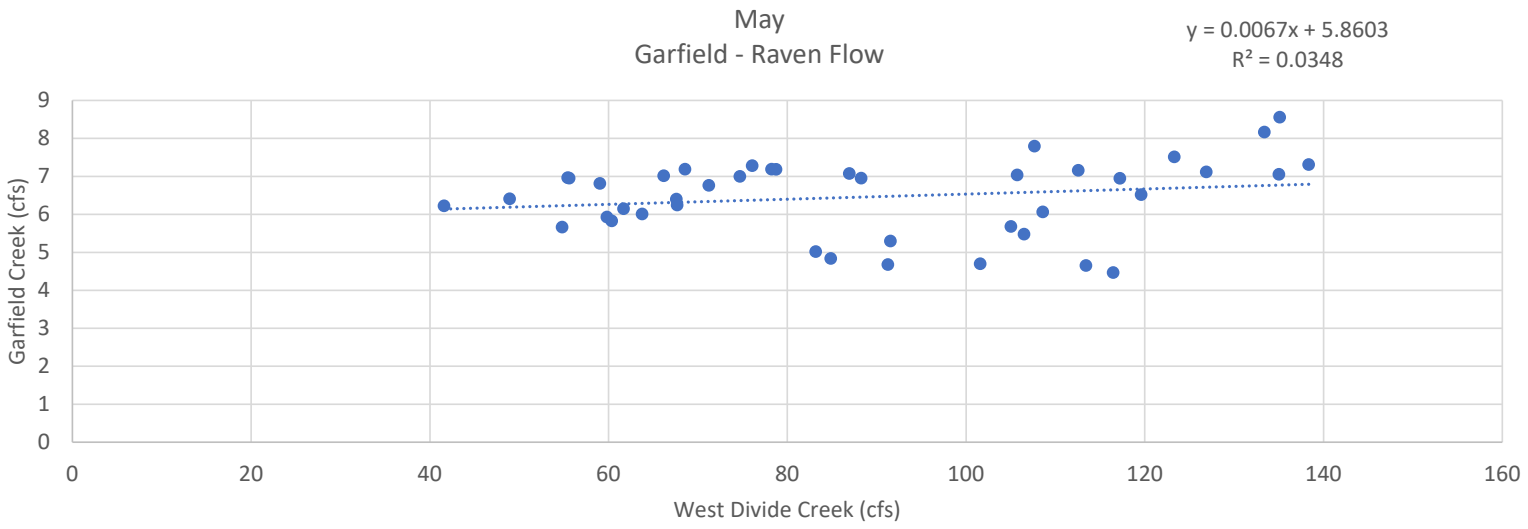
East Divide Creek

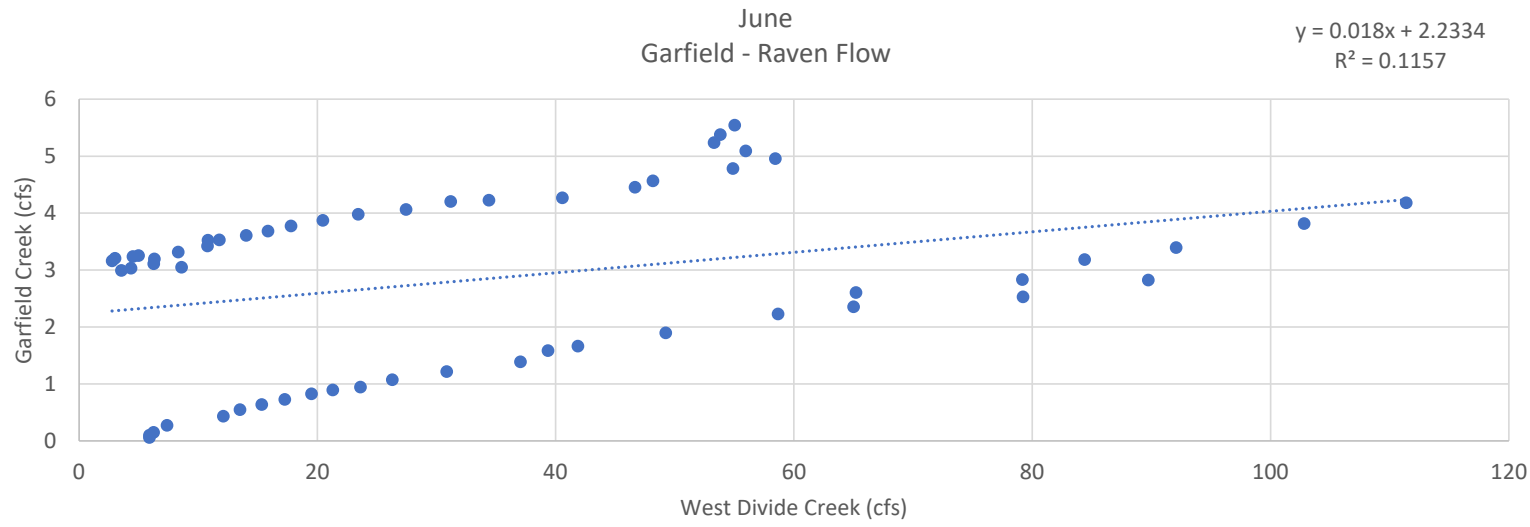


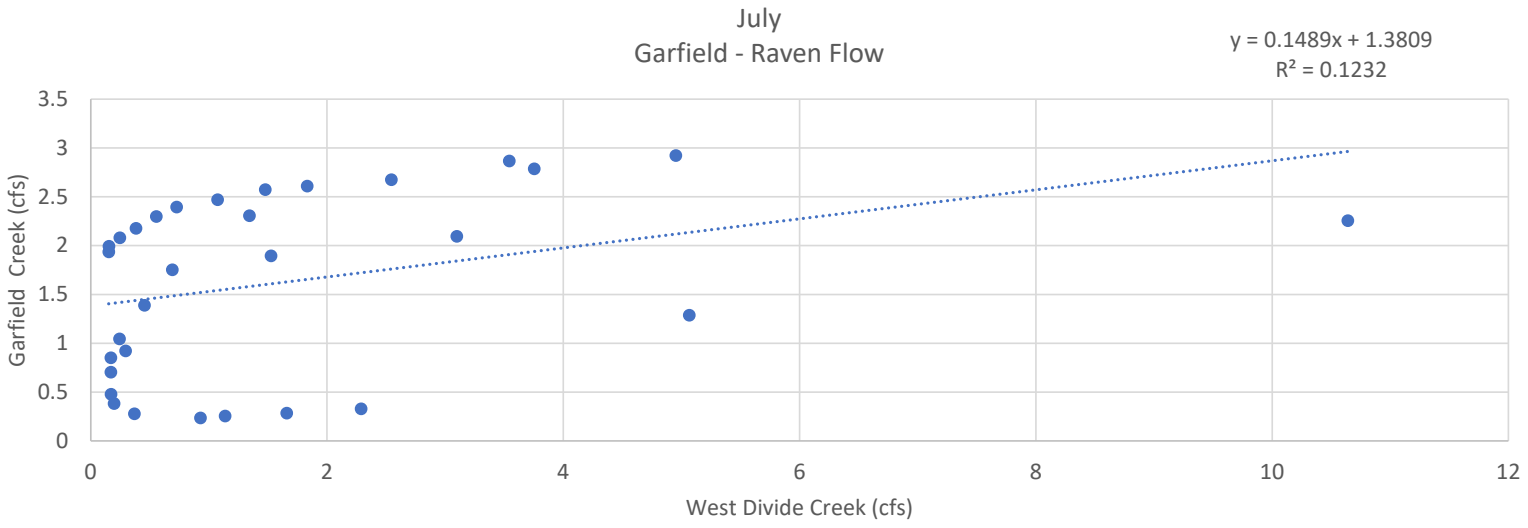




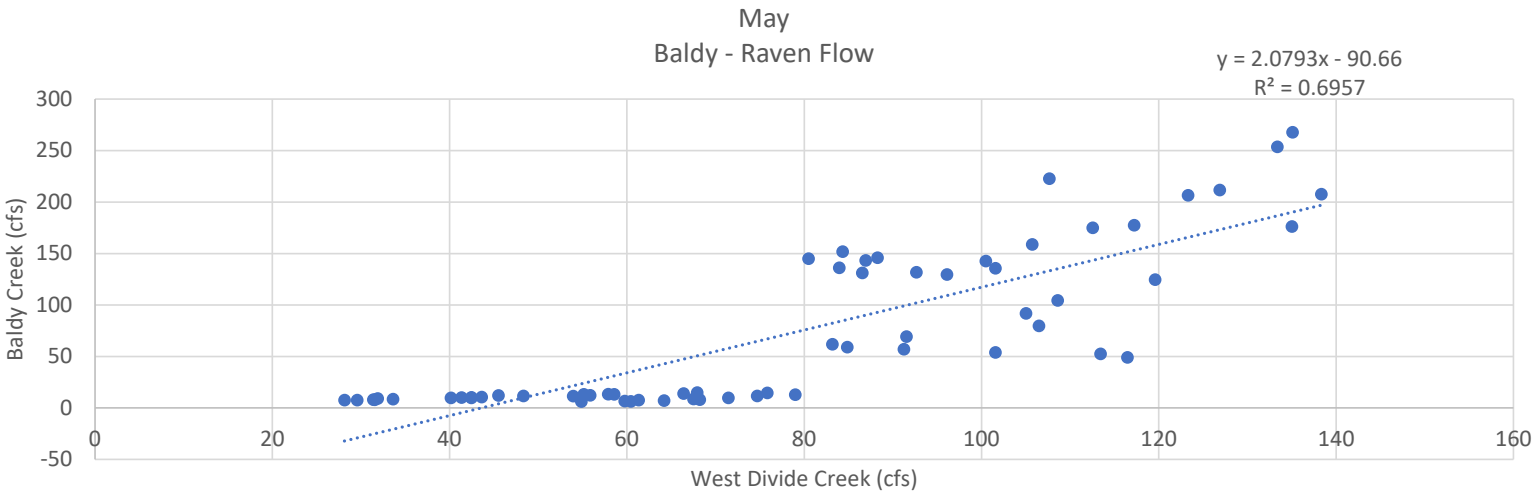
Garfield Creek

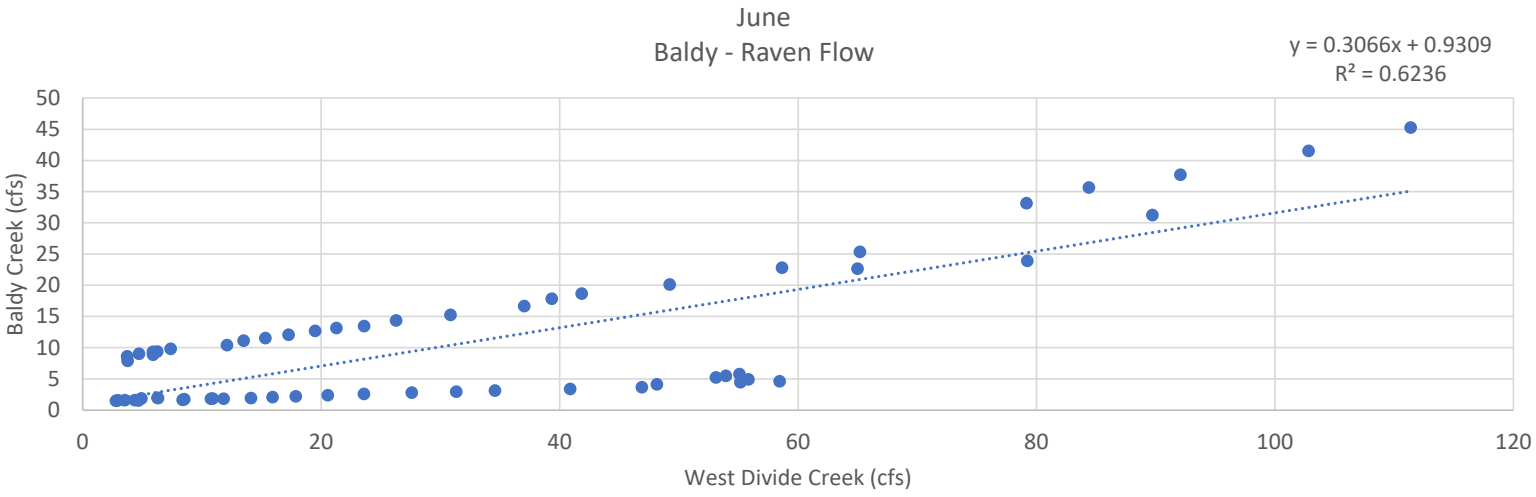


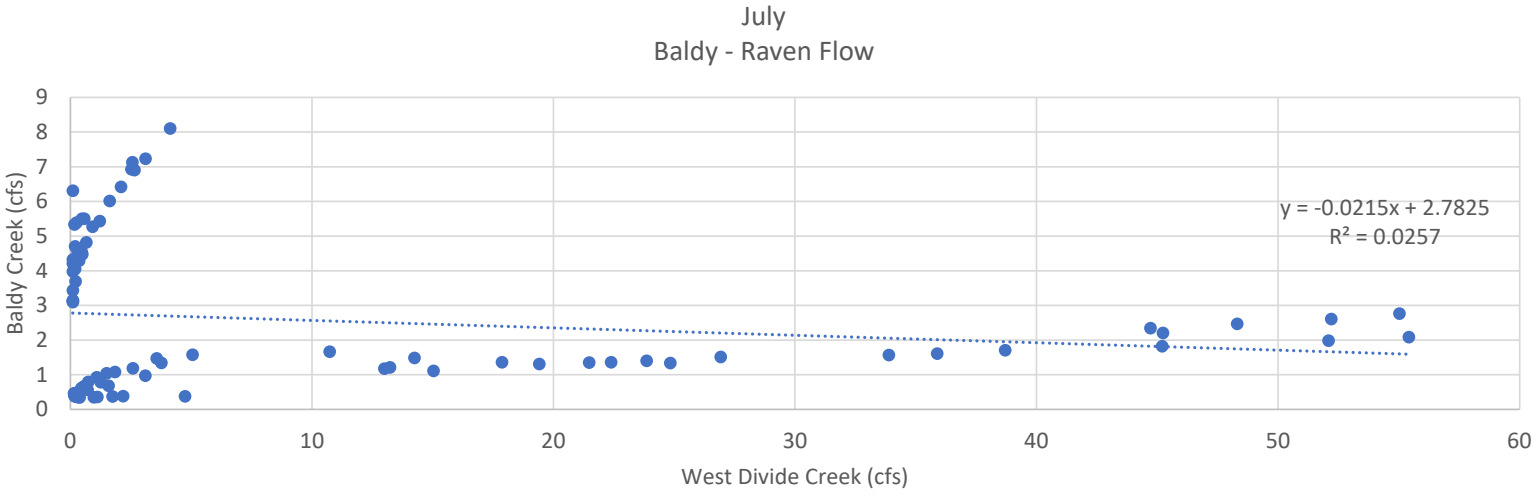




Baldy Creek


May
Baldy - Raven Flow
y = 2.0793x - 90.66
R² = 0.6957
Baldy Creek (cfs)
West Divide Creek (cfs)
300
250
200
150
100
50
0
-50
0
20
40
60
80
100
120
140
160


June
Baldy - Raven Flow
y = 0.3066x + 0.9309
R² = 0.6236
Baldy Creek (cfs)
West Divide Creek (cfs)
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120


July
Baldy - Raven Flow
y = -0.0215x + 2.7825
R² = 0.0257
Baldy Creek (cfs)
West Divide Creek (cfs)
9
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50
60

Appendix C: Water Yield Time Series

Garfield and Baldy Creek Water Right Yields

Available Flow - Diversion Based (AF)

	April	May	June	July	August	September	October	Total
2020	0.0	56.9	0.0	0.0	0.0	0.0	0.0	56.9
2021	0.0	0.0	258.4	367.7	307.5	0.0	0.0	933.6
2022	0.0	0.0	278.3	0.0	0.0	0.0	0.0	278.3
2023	0.0	0.0	1152.4	0.0	0.0	0.0	0.0	1152.4
Avg	**0.0**	**14.2**	**422.3**	**91.9**	**76.9**	**0.0**	**0.0**	**605.3**

Available Flow - Tabulation Based (AF)

	April	May	June	July	August	September	October	Total
2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2021	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Divide Creek Water Right Yields

Available Flow - Diversion Based (AF)

	April	May	June	July	August	September	October	Total
2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2021	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2022	0.0	0.0	0.0	32.7	86.0	248.0	25.5	392.2
2023	7347.9	33897.2	3570.9	12.9	0.0	0.0	0.0	44828.8
Avg	**1837.0**	**8474.3**	**892.7**	**11.4**	**21.5**	**62.0**	**6.4**	**11305.3**

Available Flow - Tabulation Based (AF)

	April	May	June	July	August	September	October	Total
2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2021	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	125.6	12949.9	0.0	0.0	0.0	0.0	0.0	13075.5
Avg	**31.4**	**3237.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3268.9**

Beaver Creek Water Right Yields

Available Flow - Diversion Based (AF)

	April	May	June	July	August	September	October	Total
2020	0.0	0.0	0.0	0.0	0.0	2.8	4.1	6.9
2021	13.2	215.3	163.7	4.0	21.0	0.0	0.0	417.2
2022	**NO DATA**							
2023	4.5	58.0	310.5	1020.5	0.0	0.0	0.0	1393.6
Avg	**5.9**	**91.1**	**158.1**	**341.5**	**7.0**	**0.9**	**1.4**	**605.9**

Available Flow - Tabulation Based (AF)

	April	May	June	July	August	September	October	Total
2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2021	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2022	**NO DATA**							
2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Cache Creek Water Right Yields								
Available Flow - Diversion Based (AF)								
	April	May	June	July	August	September	October	Total
2020	44.4	102.3	330.4	281.9	217.9	262.6	200.3	1440.0
2021	0.0	0.0	76.1	0.0	0.0	0.0	0.0	76.1
2022	2.4	17.4	22.4	0.0	5.8	0.0	0.0	48.0
2023	0.0	20687.3	4704.2	0.0	0.0	0.0	0.0	25391.4
Avg	**11.7**	**5201.7**	**1283.3**	**70.5**	**55.9**	**65.7**	**50.1**	**6738.9**
Available Flow - Tabulation Based (AF)								
	April	May	June	July	August	September	October	Total
2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2021	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	0.0	19970.7	3299.0	0.0	0.0	0.0	0.0	23269.7
Avg	**0.0**	**4992.7**	**824.7**	**0.0**	**0.0**	**0.0**	**0.0**	**5817.4**

Battlement Creek Water Right Yields								
Available Flow - Diversion Based (AF)								
	April	May	June	July	August	September	October	Total
2020	1.5	0.0	0.0	0.0	0.0	0.0	0.0	1.5
2021	16.7	26.8	0.0	1.1	0.0	0.0	0.0	44.6
2022	0.0	49.1	0.0	0.0	0.0	0.0	0.0	49.1
2023	**NO DATA**							
Avg	**6.1**	**25.3**	**0.0**	**0.4**	**0.0**	**0.0**	**0.0**	**31.7**
Available Flow - Tabulation Based (AF)								
	April	May	June	July	August	September	October	Total
2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2021	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	**NO DATA**							
Avg	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**