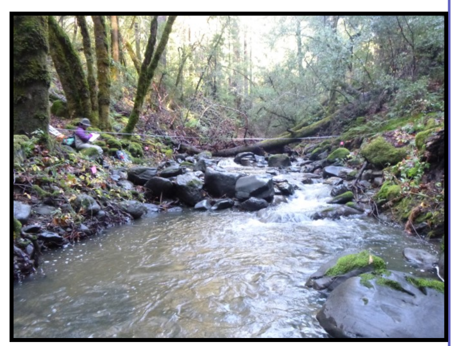
Watershed-Wide Instream Flow Criteria for Mark West Creek



California Department of Fish and Wildlife
Instream Flow Program

June 2022

Watershed Criteria Report No. 2022–01

California Department of Fish and Wildlife
Water Branch
Instream Flow Program
Watershed Criteria Report No. 2022–01

Prepared by:

Sean Windell[a], Instream Flow Program Senior Environmental Scientist

James Allen, Instream Flow Program Fish and Wildlife Technician

Brionna Drescher[b], Instream Flow Program Senior Environmental Scientist

California Department of Fish and Wildlife, West Sacramento, California

The California Department of Fish & Wildlife
INSTREAM
FLOW PROGRAM

Suggested citation:

CDFW (2022). Watershed-Wide Instream Flow Criteria for Mark West Creek. California Department of Fish and Wildlife, Instream Flow Program (CDFW), West Sacramento, CA. Watershed Criteria Report No. 2022–01.

[a] Project Lead, [b] Quality Assurance Officer

Table of Contents

FIGURES

TABLES

Introduction

This *Watershed-Wide Instream Flow Criteria* report (Watershed Criteria Report) provides instream flow criteria for the Mark West Creek watershed, based on the best available scientific information, existing and new datasets, analysis, and fieldwork. Its intended audience includes agencies, water managers, non-governmental organizations, and the public.

Mark West Creek was identified as a priority stream in the California Water Action Plan (CNRA et al. 2016). Accordingly, the California Department of Fish and Wildlife (Department) initiated studies in Mark West Creek, as described in the *Habitat and Instream Flow Evaluation for Anadramous Steelhead and Coho Salmon in Upper Mark West Creek, Sonoma County* study plan (CDFW 2018a). This Watershed Criteria Report presents a portion of the results from this study. An additional report, *Instream Flow Evaluation: Juvenile Rearing of Steelhead and Coho Salmon in Upper Mark West Creek, Sonoma County* (Carlin et al. in prep.), provides site-specific information for Mark West Creek.

This report presents stream assessments for 25 reaches and seven site-specific field surveys. An overview of the analyses used to create instream flow regime criteria contained in this document, as well as examples of potential criteria applications, are found in the Department's *Overview for Watershed-Wide Instream Flow Criteria Report Methodology* (Overview) document (CDFW 2021). Reviewing and understanding the information contained in the Overview document is essential to understanding flow criteria contained in this report. Complete background files for this report are maintained in the Department's Headquarters office. This document and the Overview may be found on the Watershed-Wide Instream Flow Criteria webpage (CDFW 2022).

The Department provides this document as a tool for consideration in water management planning. It presents an analytical approach that can be implemented, if appropriate, under the specific circumstances of a watershed, stream, or informational need. This report and the Overview, in and of themselves, should not be considered to provide binding guidelines.

Mark West Creek
MARK WEST CREEK WATERSHED, SONOMA COUNTY

Mark West Creek Watershed

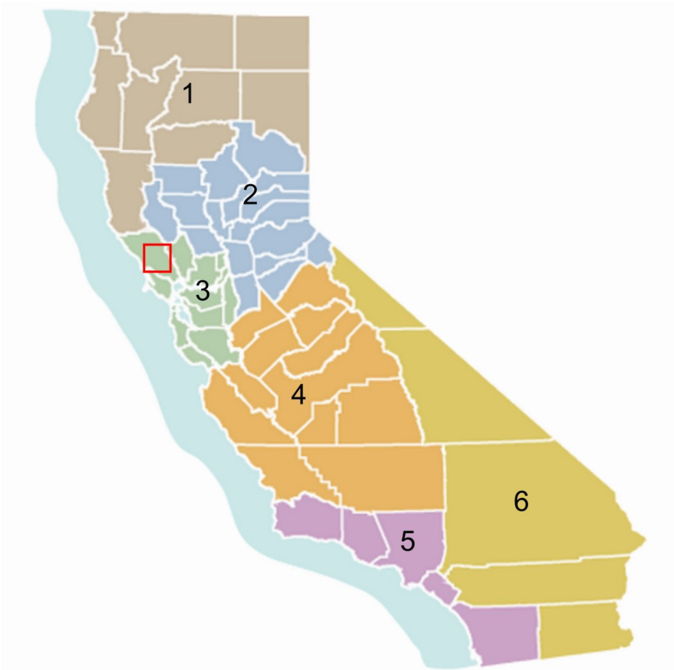


Figure 1. Map of the Department's Regions.

- Located in the Department's Region 3
- Within Sonoma County
- 254-square-mile (mi^2) drainage area
- Supports steelhead and Coho Salmon

Mark West Creek
MARK WEST CREEK WATERSHED, SONOMA COUNTY

In this map (Figure 2), yellow indicates steelhead-bearing streams (Shannon and Christy 2012) and the orange shapes are United States Geological Survey (USGS) gages. Criteria were developed for each numbered reach. The common identifiers (COMIDs) that correspond to the numbered reaches are listed in Appendix A.

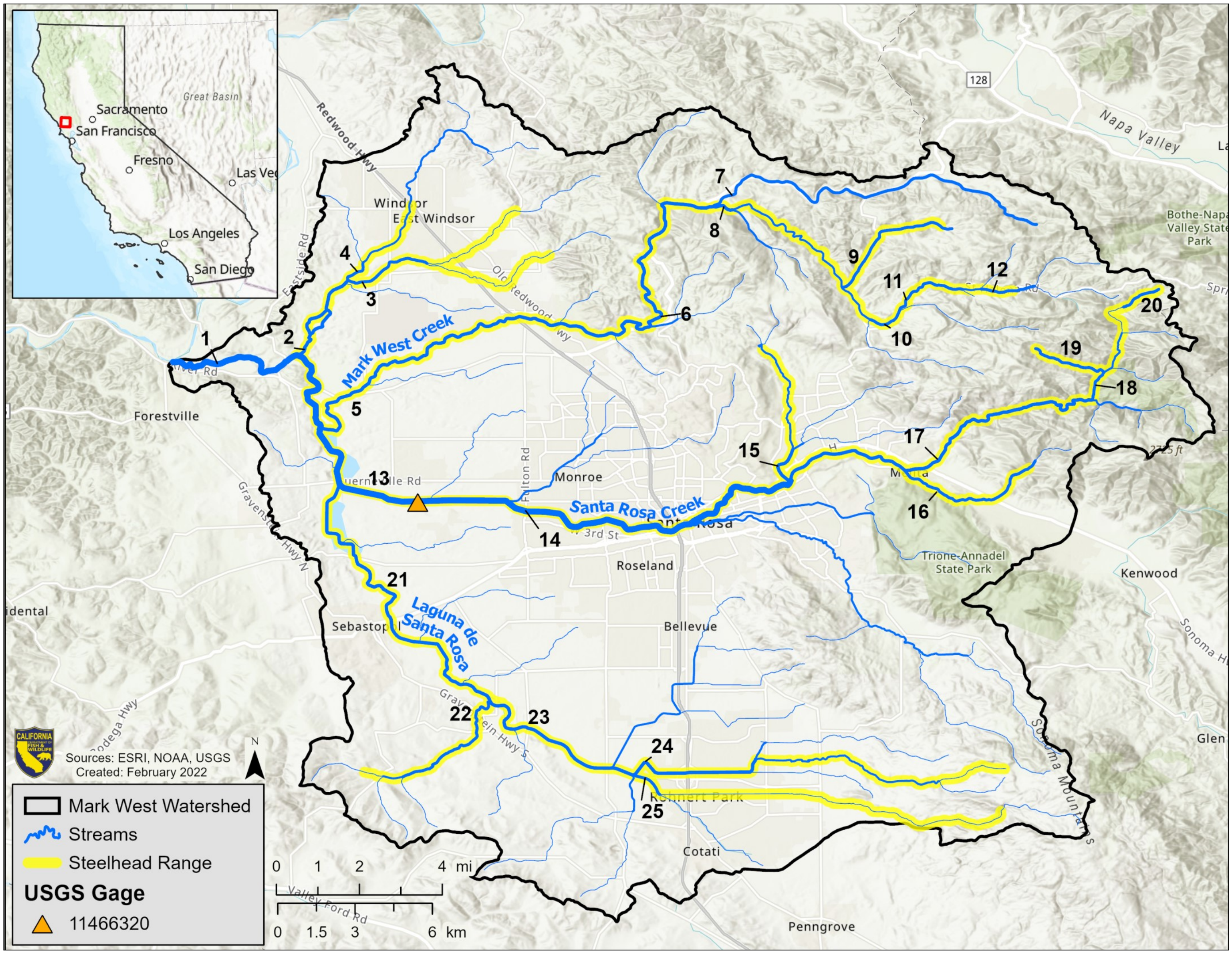


Figure 2. Mark West Creek watershed map.

1) Mark West Creek 1
2) Windsor Creek 1
3) Pool Creek
4) Windsor Creek 2
5) Mark West Creek 2
6) Mark West Creek 3
7) Porter Creek
8) Mark West Creek 4
9) Humbug Creek
10) Mark West Creek 5
11) Mark West Creek 6
12) Mark West Creek 7
13) Santa Rosa Creek 1
14) Santa Rosa Creek 2
15) Rincon Creek
16) Tributary 1
17) Santa Rosa Creek 3
18) Santa Rosa Creek 4
19) Salt Creek
20) Santa Rosa Creek 5
21) Laguna de Santa Rosa 1
22) Blucher Creek
23) Laguna de Santa Rosa 2
24) Tributary 2
25) Laguna de Santa Rosa 3

The summaries in Figure 3 provide an overview of analyses presented in this Watershed Criteria Report. For more details on each analysis see the Overview, which can be found through the Watershed-Wide Instream Flow Criteria webpage (CDFW 2022).

Flow Variation	Annual and interannual variation in flows is critical to long-term ecological functioning. These data provide an example of natural variation in the selected watershed.
Median Natural Flows	Median natural flows present estimated natural streamflow data by water month type for each reach.
Functional Flows	Functional flows perform key ecological and geomorphic functions. This section presents information on the timing, magnitude, and duration of key functional flows within the annual hydrologic cycle.
Ecosystem Baseflows	Ecosystem baseflows are monthly baseflows that preserve a healthy stream ecosystem. These are calculated as a percentage of monthly and annual natural flows and vary throughout the year.
Salmonid Habitat Optimum Flows	Salmonid habitat optimum flows provide optimal access to preferred salmonid habitat. This section presents the optimal discharge for select salmonid life stages for each stream reach.
Sensitive Period Indicators	Sensitive period indicator flows can be used to identify the sensitive low-flow period. During this period, fish and wildlife may be particularly sensitive to flow reductions. These flows can be determined using a field-based analysis.
Salmonid Passage Flows	Salmonid passage flows provide enough water for salmonids to cross riffles, which are typically the shallowest part of a channel. These flows are determined using a field-based analysis.

Figure 3. Watershed criteria methods key.

Flow Variation

Flows in the Mark West Creek watershed are variable throughout the year and from year to year. The gage presented below (Figure 4), located on Santa Rosa Creek, was selected because it represents the current hydrologic patterns in the Mark West Creek watershed. However, it is important to note that the Mark West Creek watershed has experienced decades of anthropogenic impacts, including land use changes and water diversions, which have resulted in changes in hydrologic patterns (CDFG 2004).

The wet season in the Mark West Creek watershed is predicted to become more intense and more variable as climate change impacts intensify (Ackerly 2018). These shifts, combined with ongoing surface and groundwater extractions, may result in higher stress to ecosystems and reduced water availability. Understanding natural variability and projected future changes to flow patterns can help water users and managers create a flow regime and plan for changes in water availability.

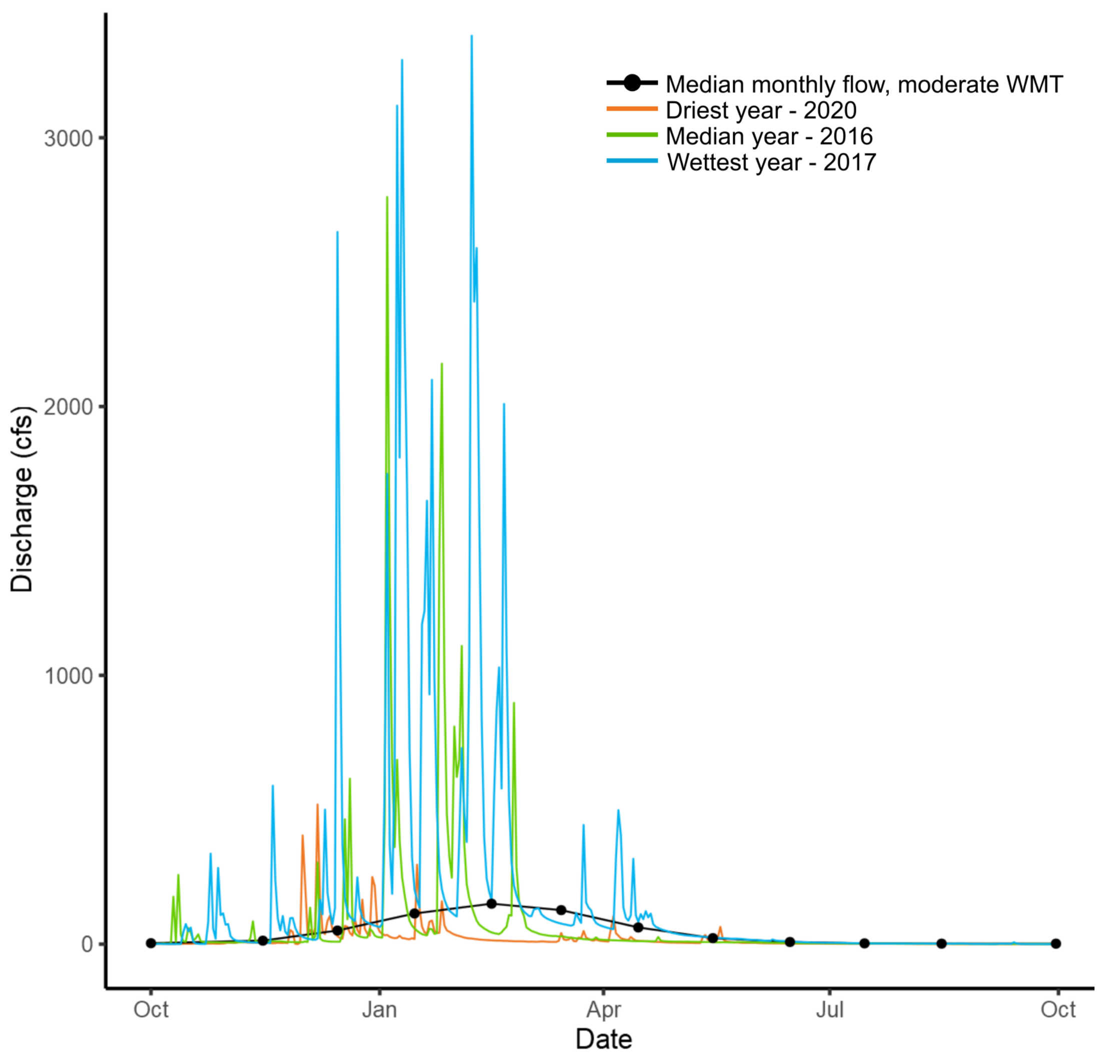


Figure 4. Variation in mean daily Santa Rosa Creek flows at USGS gage 11466320, located in the Mark West Creek watershed, in extreme and median conditions (i.e., the driest, median, and wettest year) between water years 2000 and 2021 (USGS 2022). Median monthly flow for a moderate water month type (WMT) is also included.

Median Natural Flows

Natural flows are the stream flows (in cfs) that would be expected with no human influence (data from Zimmerman et al. 2021). Table 1 presents monthly median natural flows by month for wet, moderate, and dry water month types for each Mark West Creek tributary and mainstem reach analyzed in this report. It also presents the drainage area in mi^2. The numbers next to each stream name correspond to the numbers found on the Mark West Creek watershed map (Figure 2).

Table 1. Median natural flows by water month type

1) Mark West Creek 1 254.4 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	998	1,043	758	430	143	47	19	11	9	16	92	447
Moderate	369	468	418	190	74	23	9	7	7	10	45	151
Dry	77	202	166	102	49	13	6	6	6	7	31	48

2) Windsor Creek 1 26.7 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	98	102	82	44	15	5	2	1	1	2	11	45
Moderate	43	47	43	19	7	2	1	1	1	2	5	16
Dry	7	19	18	10	5	1	1	1	1	1	4	6

3) Pool Creek 10.0 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	39	41	31	17	6	2	1	1	1	1	4	18
Moderate	16	19	17	7	3	1	1	<1	<1	1	2	7
Dry	3	8	7	4	2	1	<1	<1	<1	1	2	2

4) Windsor Creek 2 11.3 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	43	45	35	19	7	2	1	1	<1	1	5	20
Moderate	20	21	19	8	3	1	<1	<1	<1	1	2	7
Dry	3	8	8	5	2	1	<1	<1	<1	<1	2	3

5) Mark West Creek 2 52.1 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	286	285	200	117	39	15	7	5	4	5	36	145
Moderate	101	129	103	50	19	8	5	3	3	4	11	55
Dry	21	54	45	25	12	5	3	2	2	2	7	11

6) Mark West Creek 3 36.2 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	236	240	146	99	34	14	6	4	3	4	30	118
Moderate	84	93	87	39	17	8	5	3	2	3	8	45
Dry	17	44	33	19	9	4	2	2	2	2	5	8

Table 1. Median natural flows (continued).

7) Porter Creek 8.3 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	52	55	39	23	8	3	1	1	1	1	7	26
Moderate	19	22	21	9	4	2	1	1	1	1	2	11
Dry	4	9	8	5	2	1	<1	<1	<1	<1	1	2

8) Mark West Creek 4 20.9 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	141	144	96	59	20	9	4	2	2	2	19	69
Moderate	54	57	52	23	10	6	3	2	1	2	5	27
Dry	10	26	20	12	5	3	1	1	1	1	3	5

9) Humbug Creek 2.8 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	19	20	13	8	3	1	1	<1	<1	<1	2	9
Moderate	7	8	7	3	1	1	<1	<1	<1	<1	1	4
Dry	1	3	3	2	1	<1	<1	<1	<1	<1	<1	1

10) Mark West Creek 5 10.0 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	70	79	48	31	10	5	2	1	1	1	11	32
Moderate	26	29	27	14	5	3	1	1	1	1	3	14
Dry	5	13	11	6	3	2	1	<1	<1	<1	2	2

11) Mark West Creek 6 6.6 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	57	57	33	21	7	3	2	1	1	1	7	21
Moderate	18	20	19	10	4	2	1	1	<1	1	2	11
Dry	4	9	8	4	2	1	<1	<1	<1	<1	1	2

12) Mark West Creek 7 4.1 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	36	37	21	14	5	2	1	<1	<1	<1	5	15
Moderate	11	13	12	6	3	1	1	<1	<1	<1	1	7
Dry	2	6	5	3	1	1	<1	<1	<1	<1	1	1

13) Santa Rosa Creek 1 78.3 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	346	371	241	142	43	17	6	4	3	5	36	144
Moderate	114	151	127	62	22	8	3	2	2	4	13	51
Dry	26	63	59	32	14	5	2	1	2	2	8	15

Table 1. Median natural flows (continued).

14) Santa Rosa Creek 2 59.5 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	294	292	196	118	37	14	5	3	2	4	37	141
Moderate	96	124	95	49	19	7	3	2	2	4	13	46
Dry	24	53	47	27	12	4	2	1	1	2	10	15

15) Rincon Creek 10.4 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	44	49	34	18	6	2	1	1	<1	1	5	19
Moderate	16	21	17	8	3	1	<1	<1	<1	<1	2	7
Dry	4	9	8	5	2	1	<1	<1	<1	<1	1	2

16) Tributary 1 8.1 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	42	41	28	16	5	2	1	1	<1	1	5	19
Moderate	14	17	13	7	3	1	1	<1	<1	1	1	6
Dry	3	7	6	4	2	1	<1	<1	<1	<1	1	2

17) Santa Rosa Creek 3 12.5 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	89	98	56	38	11	4	2	1	1	1	13	43
Moderate	35	38	31	15	5	2	1	1	<1	1	3	17
Dry	6	16	13	8	3	1	<1	<1	<1	<1	2	3

18) Santa Rosa Creek 4 5.2 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	48	47	27	20	6	2	1	1	1	1	7	18
Moderate	15	16	16	8	3	1	1	<1	<1	<1	1	8
Dry	3	7	6	4	2	1	<1	<1	<1	<1	1	1

19) Salt Creek 1.1 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	10	10	5	4	1	1	<1	<1	<1	<1	1	4
Moderate	3	3	3	2	1	<1	<1	<1	<1	<1	<1	2
Dry	1	2	1	1	<1	<1	<1	<1	<1	<1	<1	<1

20) Santa Rosa Creek 5 0.4 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	7	7	4	3	1	<1	<1	<1	<1	<1	1	3
Moderate	2	2	2	1	<1	<1	<1	<1	<1	<1	<1	1
Dry	1	1	1	1	<1	<1	<1	<1	<1	<1	<1	<1

Table 1. Median natural flows (continued).

21) Laguna de Santa Rosa 1 79.7 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	246	242	157	108	33	12	5	3	4	5	22	94
Moderate	74	94	96	45	20	6	3	3	4	4	12	30
Dry	15	51	36	23	11	4	2	3	4	2	9	14

22) Blucher Creek 7.7 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	27	28	19	12	4	2	1	<1	<1	<1	3	13
Moderate	11	12	12	6	2	1	<1	<1	<1	<1	2	4
Dry	2	6	5	3	1	1	<1	<1	<1	<1	1	2

23) Laguna de Santa Rosa 2 43.7 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	129	139	87	55	17	7	3	2	2	3	12	53
Moderate	39	51	52	23	11	3	2	2	2	2	6	16
Dry	8	29	19	11	6	2	1	1	2	1	4	7

24) Tributary 2 9.3 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	32	33	23	12	4	2	1	<1	<1	1	3	15
Moderate	10	15	12	5	3	1	<1	<1	<1	1	1	4
Dry	2	7	5	3	2	1	<1	<1	<1	<1	1	1

25) Laguna de Santa Rosa 3 12.1 mi^2

Month Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	39	45	29	15	5	2	1	<1	<1	1	3	17
Moderate	12	18	15	7	3	1	<1	<1	1	1	2	4
Dry	3	9	6	3	2	1	<1	<1	<1	<1	1	2


Mark West Creek
MARK WEST CREEK WATERSHED, SONOMA COUNTY

Functional Flows

This section presents tables illustrating modeled functional flows in the Mark West Creek watershed (data from CEFWG 2021). Table 2–Table 7 are representative of the mainstem Mark West Creek watershed, as well as its tributaries. Functional flow timing throughout the watershed is likely consistent, but magnitudes differ (Rodríguez-Iturbe and Valdés 1979).

Mark West Creek
MARK WEST CREEK WATERSHED, SONOMA COUNTY

Table 2. Lower Mark West Creek functional flow metric median values, 10th–90th percentile in parentheses. Results provided by water year type (wet, moderate, dry). Results are based on modeled functional flows for reach Mark West Creek 1.

Metric	Wet Years	Moderate Years	Dry Years
Fall pulse flow magnitude (cfs)	226 (39–1,450)	159 (35–1,090)	135 (31–697)
Fall pulse flow duration (total days per year, when present)	4 (2–9)*	4 (2–9)*	4 (2–9)*
Fall pulse flow start timing	Oct 24 (Oct 7–Nov 16)	Oct 27 (Oct 7–Nov 20)	Nov 1 (Oct 8–Nov 25)
Wet-season baseflow magnitude (cfs)	144 (58–314)	87 (28–199)	43 (13–118)
Median wet-season flow magnitude (cfs)	550 (270–1,050)	320 (174–650)	164 (46–460)
Wet-season duration (days)	126 (78–163)	105 (63–153)	92 (50–157)
Wet-season start timing	Dec 3 (Nov 14–Dec 15)	Dec 2 (Nov 15–Dec 26)	Dec 13 (Nov 7–Jan 22)
2-year peak flow magnitude (cfs)	7,840 (2,680–14,400)	7,840 (2,680–14,400)	7,840 (2,680–14,400)
2-year peak flow duration (total days per year, when present)	3 (1–16)*	3 (1–16)*	3 (1–16)*
2-year peak flow frequency (events per year, when present)	2 (1–5)*	2 (1–5)*	2 (1–5)*
5-year peak flow magnitude (cfs)	10,600 (4,970–23,000)	10,600 (4,970–23,000)	10,600 (4,970–23,000)
5-year peak flow duration (total days per year, when present)	1 (1–5)*	1 (1–5)*	1 (1–5)*
5-year peak flow frequency (events per year, when present)	1 (1–3)*	1 (1–3)*	1 (1–3)*
Spring recession flow magnitude (cfs)	2,460 (731–9,510)	1,820 (499–6,430)	1,300 (249–5,080)
Spring recession flow duration (days)	42 (25–105)	45 (24–114)	49 (23–124)
Spring recession flow start timing	Apr 10 (Mar 8–May 4)	Mar 27 (Mar 5–Apr 17)	Mar 28 (Mar 4–May 3)
Spring recession flow rate of change (%)	7 (4–17)*	7 (4–17)*	7 (4–17)*
Dry-season baseflow magnitude (cfs)	15 (4–40)	11 (1–25)	5 (<1–16)
Dry-season duration (days)	203 (149–252)	197 (135–262)	203 (135–264)
Dry-season start timing	May 25 (Apr 23–Jun 27)	May 26 (Apr 13–Jul 10)	May 26 (Apr 12–Jul 29)

* indicates a metric with inferred ranges that was not modeled by water year type

Table 3. Middle Mark West Creek functional flow metric median values, 10th–90th percentile in parentheses. Results provided by water year type (wet, moderate, dry). Results are based on modeled functional flows for reach Mark West Creek 3.

Metric	Wet Years	Moderate Years	Dry Years
Fall pulse flow magnitude (cfs)	39 (11–183)	22 (6–128)	18 (5–69)
Fall pulse flow duration (total days per year, when present)	4 (2–9)*	4 (2–9)*	4 (2–9)*
Fall pulse flow start timing	Oct 22 (Oct 7–Nov 8)	Oct 27 (Oct 9–Nov 17)	Oct 28 (Oct 8–Nov 20)
Wet-season baseflow magnitude (cfs)	34 (15–63)	19 (8–40)	10 (3–22)
Median wet-season flow magnitude (cfs)	141 (81–251)	72 (38–128)	34 (16–73)
Wet-season duration (days)	124 (83–167)	117 (68–156)	90 (51–149)
Wet-season start timing	Dec 1 (Nov 15–Dec 15)	Dec 2 (Nov 17–Dec 18)	Dec 13 (Nov 13–Jan 19)
2-year peak flow magnitude (cfs)	1,360 (474–2,580)	1,360 (474–2,580)	1,360 (474–2,580)
2-year peak flow duration (total days per year, when present)	3 (1–10)*	3 (1–10)*	3 (1–10)*
2-year peak flow frequency (events per year, when present)	2 (1–5)*	2 (1–5)*	2 (1–5)*
5-year peak flow magnitude (cfs)	1,960 (829–3,750)	1,960 (829–3,750)	1,960 (829–3,750)
5-year peak flow duration (total days per year, when present)	1 (1–4)*	1 (1–4)*	1 (1–4)*
5-year peak flow frequency (events per year, when present)	1 (1–2)*	1 (1–2)*	1 (1–2)*
Spring recession flow magnitude (cfs)	643 (178–2,060)	398 (93–1,280)	273 (68–857)
Spring recession flow duration (days)	39 (26–86)	42 (25–91)	48 (26–103)
Spring recession flow start timing	Apr 8 (Mar 9–Apr 28)	Mar 31 (Mar 6–Apr 30)	Mar 27 (Mar 8–Apr 30)
Spring recession flow rate of change (%)	7 (4–15)*	7 (4–15)*	7 (4–15)*
Dry-season baseflow magnitude (cfs)	4 (1–12)	3 (1–8)	2 (<1–6)
Dry-season duration (days)	192 (148–248)	191 (143–245)	194 (138–256)
Dry-season start timing	May 24 (Apr 30–Jun 23)	May 26 (Apr 17–Jun 30)	Jun 3 (Apr 16–Jul 4)

* indicates a metric with inferred ranges that was not modeled by water year type

Table 4. Upper Mark West Creek functional flow metric median values, 10th–90th percentile in parentheses. Results provided by water year type (wet, moderate, dry). Results are based on modeled functional flows for reach Mark West Creek 5.

Metric	Wet Years	Moderate Years	Dry Years
Fall pulse flow magnitude (cfs)	15 (3–102)	7 (2–44)	5 (1–24)
Fall pulse flow duration (total days per year, when present)	4 (2–9)*	4 (2–9)*	4 (2–9)*
Fall pulse flow start timing	Oct 22 (Oct 8–Nov 13)	Oct 27 (Oct 9–Nov 21)	Oct 27 (Oct 8–Nov 21)
Wet-season baseflow magnitude (cfs)	11 (4–20)	6 (2–12)	3 (1–6)
Median wet-season flow magnitude (cfs)	44 (23–84)	21 (12–39)	11 (5–22)
Wet-season duration (days)	128 (74–175)	114 (66–154)	94 (54–151)
Wet-season start timing	Nov 30 (Nov 13–Dec 15)	Dec 10 (Nov 18–Dec 31)	Dec 11 (Nov 15–Jan 17)
2-year peak flow magnitude (cfs)	327 (109–717)	327 (109–717)	327 (109–717)
2-year peak flow duration (total days per year, when present)	3 (1–10)*	3 (1–10)*	3 (1–10)*
2-year peak flow frequency (events per year, when present)	2 (1–5)*	2 (1–5)*	2 (1–5)*
5-year peak flow magnitude (cfs)	539 (251–979)	539 (251–979)	539 (251–979)
5-year peak flow duration (total days per year, when present)	1 (1–4)*	1 (1–4)*	1 (1–4)*
5-year peak flow frequency (events per year, when present)	1 (1–2)*	1 (1–2)*	1 (1–2)*
Spring recession flow magnitude (cfs)	205 (54–684)	128 (32–397)	80 (20–260)
Spring recession flow duration (days)	42 (26–95)	43 (25–93)	48 (26–103)
Spring recession flow start timing	Apr 8 (Mar 5–Apr 29)	Apr 1 (Mar 7–May 2)	Mar 28 (Mar 8–May 1)
Spring recession flow rate of change (%)	7 (4–15)*	7 (4–15)*	7 (4–15)*
Dry-season baseflow magnitude (cfs)	1 (<1–3)	1 (<1–2)	1 (<1–2)
Dry-season duration (days)	194 (144–249)	187 (142–246)	194 (138–259)
Dry-season start timing	May 22 (Apr 28–Jun 24)	May 28 (Apr 18–Jul 1)	Jun 1 (Apr 17–Jul 9)

* indicates a metric with inferred ranges that was not modeled by water year type

Table 5. Lower Santa Rosa Creek functional flow metric median values, 10^{th}–90^{th} percentile in parentheses. Results provided by water year type (wet, moderate, dry). Results are based on modeled functional flows for reach Santa Rosa Creek 2.

Metric	Wet Years	Moderate Years	Dry Years
Fall pulse flow magnitude (cfs)	51 (12–278)	36 (9–223)	31 (7–160)
Fall pulse flow duration (total days per year, when present)	4 (2–9)*	4 (2–9)*	4 (2–9)*
Fall pulse flow start timing	Oct 22 (Oct 8–Nov 15)	Oct 28 (Oct 8–Nov 19)	Oct 28 (Oct 9–Nov 24)
Wet-season baseflow magnitude (cfs)	45 (18–77)	24 (9–48)	12 (4–33)
Median wet-season flow magnitude (cfs)	158 (78–296)	90 (48–174)	41 (15–109)
Wet-season duration (days)	124 (77–160)	112 (66–158)	87 (50–153)
Wet-season start timing	Dec 3 (Nov 15–Dec 13)	Dec 2 (Nov 15–Dec 29)	Dec 20 (Nov 13–Jan 23)
2-year peak flow magnitude (cfs)	2,230 (663–3,360)	2,230 (663–3,360)	2,230 (663–3,360)
2-year peak flow duration (total days per year, when present)	3 (1–16)*	3 (1–16)*	3 (1–16)*
2-year peak flow frequency (events per year, when present)	2 (1–5)*	2 (1–5)*	2 (1–5)*
5-year peak flow magnitude (cfs)	3,040 (1,240–	3,040 (1,240–	3,040 (1,240–
5-year peak flow duration (total days per year, when present)	1 (1–5)*	1 (1–5)*	1 (1–5)*
5-year peak flow frequency (events per year, when present)	1 (1–3)*	1 (1–3)*	1 (1–3)*
Spring recession flow magnitude (cfs)	800 (224–2,480)	480 (124–1,740)	390 (89–1,370)
Spring recession flow duration (days)	40 (25–86)	43 (24–98)	48 (24–117)
Spring recession flow start timing	Apr 4 (Mar 8–Apr 29)	Mar 29 (Mar 7–Apr 28)	Mar 28 (Mar 5–Apr 27)
Spring recession flow rate of change (%)	7 (4–17)*	7 (4–17)*	7 (4–17)*
Dry-season baseflow magnitude (cfs)	4 (1–13)	3 (1–10)	2 (<1–11)
Dry-season duration (days)	201 (152–256)	195 (140–254)	203 (137–263)
Dry-season start timing	May 24 (Apr 24–Jun 21)	May 24 (Apr 16–Jul 1)	May 31 (Apr 12–Jul 8)

* indicates a metric with inferred ranges that was not modeled by water year type

Table 6. Upper Santa Rosa Creek functional flow metric median values, 10th–90th percentile in parentheses. Results provided by water year type (wet, moderate, dry). Results are based on modeled functional flows for reach Santa Rosa Creek 3.

Metric	Wet Years	Moderate Years	Dry Years
Fall pulse flow magnitude (cfs)	17 (4–76)	8 (3–45)	6 (2–28)
Fall pulse flow duration (total days per year, when present)	4 (2–9)*	4 (2–9)*	4 (2–9)*
Fall pulse flow start timing	Oct 22 (Oct 8–Nov 9)	Oct 27 (Oct 9–Nov 19)	Oct 27 (Oct 9–Nov 18)
Wet-season baseflow magnitude (cfs)	13 (6–25)	7 (3–15)	3 (1–7)
Median wet-season flow magnitude (cfs)	50 (28–94)	27 (14–51)	12 (6–26)
Wet-season duration (days)	127 (81–172)	114 (67–153)	91 (53–149)
Wet-season start timing	Nov 30 (Nov 15–Dec 15)	Dec 11 (Nov 19–Jan 2)	Dec 13 (Nov 18–Jan 15)
2-year peak flow magnitude (cfs)	610 (222–955)	610 (222–955)	610 (222–955)
2-year peak flow duration (total days per year, when present)	3 (1–10)*	3 (1–10)*	3 (1–10)*
2-year peak flow frequency (events per year, when present)	2 (1–5)*	2 (1–5)*	2 (1–5)*
5-year peak flow magnitude (cfs)	759 (395–1,320)	759 (395–1,320)	759 (395–1,320)
5-year peak flow duration (total days per year, when present)	1 (1–4)*	1 (1–4)*	1 (1–4)*
5-year peak flow frequency (events per year, when present)	1 (1–2)*	1 (1–2)*	1 (1–2)*
Spring recession flow magnitude (cfs)	229 (64–719)	133 (35–417)	92 (27–285)
Spring recession flow duration (days)	40 (25–84)	41 (25–86)	47 (26–100)
Spring recession flow start timing	Apr 8 (Mar 11–Apr 29)	Mar 29 (Mar 3–May 1)	Mar 28 (Mar 9–Apr 26)
Spring recession flow rate of change (%)	7 (4–15)*	7 (4–15)*	7 (4–15)*
Dry-season baseflow magnitude (cfs)	1 (<1–4)	1 (<1–2)	<1 (<1–1)
Dry-season duration (days)	193 (149–248)	192 (142–248)	199 (146–262)
Dry-season start timing	May 23 (May 1–Jun 23)	May 26 (Apr 17–Jun 23)	May 31 (Apr 14–Jul 2)

* indicates a metric with inferred ranges that was not modeled by water year type

Table 7. Laguna de Santa Rosa functional flow metric median values, 10th–90th percentile in parentheses. Results provided by water year type (wet, moderate, dry). Results are based on modeled functional flows for reach Laguna de Santa Rosa 1.

Metric	Wet Years	Moderate Years	Dry Years
Fall pulse flow magnitude (cfs)	65 (12–404)	46 (10–357)	36 (8–225)
Fall pulse flow duration (total days per year, when present)	4 (2–9)*	4 (2–9)*	4 (2–9)*
Fall pulse flow start timing	Oct 24 (Oct 7–Nov 21)	Oct 30 (Oct 9–Nov 23)	Nov 6 (Oct 7–Nov 29)
Wet-season baseflow magnitude (cfs)	35 (13–75)	19 (6–49)	8 (2–25)
Median wet-season flow magnitude (cfs)	132 (66–255)	78 (35–179)	29 (9–100)
Wet-season duration (days)	110 (66–157)	100 (57–151)	88 (48–158)
Wet-season start timing	Dec 10 (Nov 14–Dec 30)	Dec 2 (Nov 15–Dec 20)	Dec 18 (Nov 7–Jan 26)
2-year peak flow magnitude (cfs)	928 (439–3,360)	928 (439–3,360)	928 (439–3,360)
2-year peak flow duration (total days per year, when present)	3 (1–16)*	3 (1–16)*	3 (1–16)*
2-year peak flow frequency (events per year, when present)	2 (1–5)*	2 (1–5)*	2 (1–5)*
5-year peak flow magnitude (cfs)	2,310 (1,240–4,890)	2,310 (1,240–4,890)	2,310 (1,240–4,890)
5-year peak flow duration (total days per year, when present)	1 (1–5)*	1 (1–5)*	1 (1–5)*
5-year peak flow frequency (events per year, when present)	1 (1–3)*	1 (1–3)*	1 (1–3)*
Spring recession flow magnitude (cfs)	798 (190–3,410)	505 (134–2,280)	352 (53–1,350)
Spring recession flow duration (days)	45 (24–118)	48 (22–123)	58 (22–136)
Spring recession flow start timing	Apr 4 (Mar 9–May 6)	Mar 25 (Feb 26–Apr 18)	Mar 28, (Feb 28–May 4)
Spring recession flow rate of change (%)	7 (4–17)*	7 (4–17)*	7 (4–17)*
Dry-season baseflow magnitude (cfs)	4 (1–11)	2 (<1–7)	1 (<1–4)
Dry-season duration (days)	208 (149–258)	205 (132–267)	203 (126–268)
Dry-season start timing	May 26 (Apr 20–Jul 7)	May 26 (Apr 8–Jul 27)	May 29 (Apr 11–Aug 12)

* indicates a metric with inferred ranges that was not modeled by water year type

Ecosystem Baseflows

In wet water month types, median monthly discharge (MMD), derived using natural flows (data from Zimmerman et al. 2021), meets or exceeds ecosystem baseflows (Tessmann 1980) for approximately eight months of the water year for most reaches in the Mark West Creek watershed.

For moderate month types, median natural flows may exceed ecosystem baseflows for approximately three months of the water year (Figure 5). This pattern is similar for most reaches in the Mark West Creek watershed.

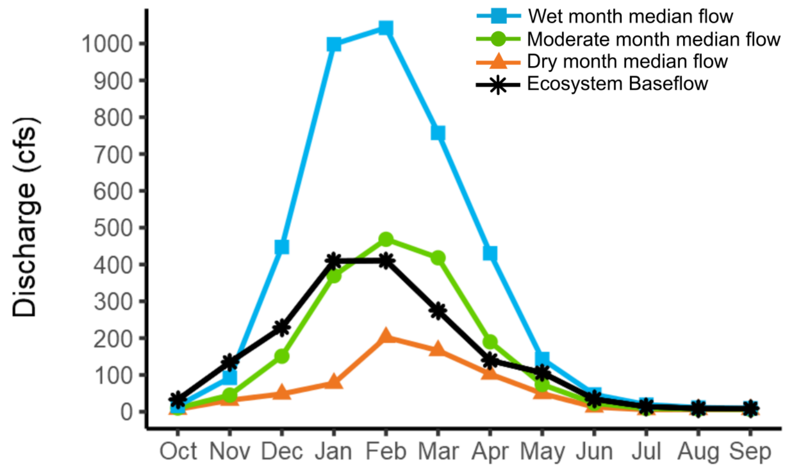


Figure 5. Ecosystem baseflows and median natural flows (Mark West Creek 1).

Mark West Creek
MARK WEST CREEK WATERSHED, SONOMA COUNTY

Ecosystem baseflows and drainage area are provided in Table 8 for each Mark West Creek tributary and mainstem reach analyzed in this report. There is one ecosystem baseflow value per month, which applies across all years. The numbers next to each stream name correspond to the numbers found on the Mark West Creek watershed map (Figure 2).

Table 8. Ecosystem baseflows.

Stream	Drainage Area (mi^2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1) Mark West Creek 1	254.4	409	411	274	139	106	34	14	9	8	32	134	229
2) Windsor Creek 1	26.7	44	44	29	14	11	4	1	1	2	3	14	23
3) Pool Creek	10.0	17	17	11	6	4	2	1	1	1	1	6	10
4) Windsor Creek 2	11.3	19	19	13	6	5	2	1	<1	1	1	6	10
5) Mark West Creek 2	52.1	108	110	77	39	31	11	6	4	4	10	37	63
6) Mark West Creek 3	36.2	83	86	60	31	27	10	5	3	3	7	29	50
7) Porter Creek	8.3	19	20	14	7	7	2	1	1	1	2	7	12
8) Mark West Creek 4	20.9	50	52	36	19	16	7	3	2	2	4	17	30
9) Humbug Creek	2.8	7	7	5	3	2	1	<1	<1	<1	1	2	4
10) Mark West Creek 5	10.0	26	27	19	10	9	3	2	1	1	2	9	16
11) Mark West Creek 6	6.6	17	19	13	7	6	2	1	1	1	2	6	11
12) Mark West Creek 7	4.1	11	12	8	5	4	2	1	<1	<1	1	4	7
13) Santa Rosa Creek 1	78.3	133	135	90	45	34	11	4	3	3	11	44	77
14) Santa Rosa Creek 2	59.5	107	112	75	37	29	10	4	2	2	9	36	61
15) Rincon Creek	10.4	18	19	12	6	5	1	1	<1	<1	1	6	10
16) Tributary 1	8.1	15	16	11	5	4	2	1	<1	<1	1	5	9
17) Santa Rosa Creek 3	12.5	32	33	22	12	10	3	1	1	1	3	11	19
18) Santa Rosa Creek 4	5.2	14	15	10	6	5	2	1	1	<1	1	5	9
19) Salt Creek	1.1	3	3	2	1	1	<1	<1	<1	<1	<1	1	2

Table 8. Ecosystem baseflows (continued).

Stream	Drainage Area (mi^2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20) Santa Rosa Creek 5	0.4	2	2	2	1	1	<1	<1	<1	<1	<1	1	1
21) Laguna de Santa Rosa 1	79.7	101	97	65	32	25	9	4	4	4	8	32	50
22) Blucher Creek	7.7	11	11	8	4	3	1	<1	<1	<1	1	4	6
23) Laguna de Santa Rosa 2	43.7	54	53	35	17	13	5	2	2	2	4	17	27
24) Tributary 2	9.3	13	13	8	4	3	1	1	<1	1	1	4	7
25) Laguna de Santa Rosa 3	12.1	16	16	11	5	4	1	1	1	1	1	5	8

Mark West Creek

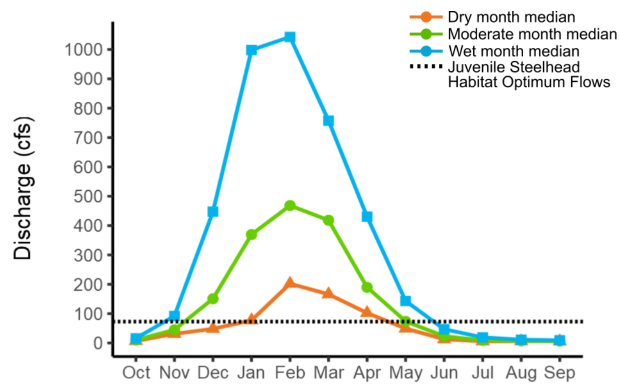
MARK WEST CREEK WATERSHED, SONOMA COUNTY

Salmonid Habitat Optimum Flows
By Monthly Duration

Figure 6 displays flows that maximize usable habitat for juvenile steelhead (Hatfield and Bruce 2000) along with median natural flows (Zimmerman et al. 2021). The information is categorized by the watershed's mainstem reaches and their tributaries (i.e. Mark West Creek, Santa Rosa Creek, and Laguna de Santa Rosa) and is sorted by drainage area. In drainages with altered flow, the period of flow below the juvenile steelhead habitat optimum flows (optimum flows) may have a longer or shorter duration than shown here.

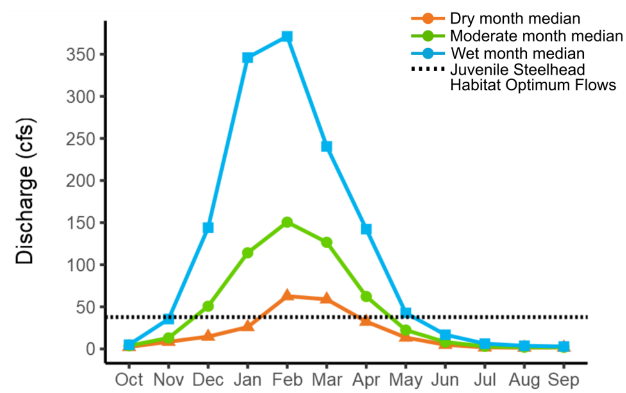
Mark West Creek and Tributaries: 2.8–254.4 mi^2

Natural flows for a moderate water month type are typically above the optimum flow for **3–6 months** of the year.



Santa Rosa Creek and Tributaries: 0.4–78.3 mi^2

Natural flows for a moderate water month type are typically above the optimum flow for **3–5 months** of the year, except for in the upper watershed (reaches 19 and 20 on map).



Laguna de Santa Rosa and Tributaries: 7.7–79.7 mi^2

Natural flows for a moderate water month type are typically above the optimum flow for **3–4 months** of the year.

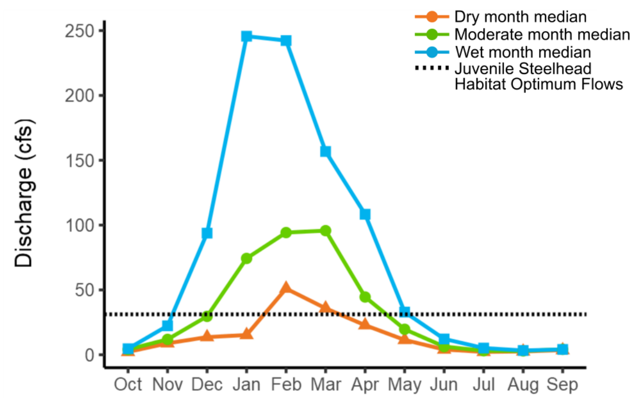


Figure 6. Juvenile steelhead optimum flows and median natural flows.

Salmonid Habitat Optimum Flows
By Drainage Area

Generally, the surface flow required to meet the juvenile steelhead optimum flows increases as the drainage area increases. Table 9 groups steelhead optimum flows by the mainstem reaches and their tributaries (i.e. Mark West Creek, Santa Rosa Creek, and Laguna de Santa Rosa). The numbers next to each stream name correspond to the numbers found on the Mark West Creek watershed map (Figure 2).

Table 9. Juvenile steelhead optimum flows (by drainage area).

Mark West Creek and Tributaries

Stream	Drainage Area (mi^2)	Juvenile Steelhead Optimum Flows (cfs)
9) Humbug Creek	2.8	7
12) Mark West Creek 7	4.1	9
11) Mark West Creek 6	6.6	12
7) Porter Creek	8.3	13
10) Mark West Creek 5	10.0	15
3) Pool Creek	10.0	11
4) Windsor Creek 2	11.3	12
8) Mark West Creek 4	20.9	22
2) Windsor Creek 1	26.7	19
6) Mark West Creek 3	36.2	30
5) Mark West Creek 2	52.1	34
1) Mark West Creek 1	254.4	73

Mark West Creek
MARK WEST CREEK WATERSHED, SONOMA COUNTY

Table 9. Juvenile steelhead optimum flows (by drainage area) (continued).

Santa Rosa Creek and Tributaries

Stream	Drainage Area (mi^2)	Juvenile Steelhead Optimum Flows (cfs)
20) Santa Rosa Creek 5	0.4	3
19) Salt Creek	1.1	4
18) Santa Rosa Creek 4	5.2	10
16) Tributary 1	8.1	11
15) Rincon Creek	10.4	11
17) Santa Rosa Creek 3	12.5	17
14) Santa Rosa Creek 2	59.5	34
13) Santa Rosa Creek 1	78.3	38

Laguna de Santa Rosa and Tributaries

Stream	Drainage Area (mi^2)	Juvenile Steelhead Optimum Flows (cfs)
22) Blucher Creek	7.7	9
24) Tributary 2	9.3	9
25) Laguna de Santa Rosa 3	12.1	10
23) Laguna de Santa Rosa 2	43.7	21
21) Laguna de Santa Rosa 1	79.7	31


Mark West Creek
MARK WEST CREEK WATERSHED, SONOMA COUNTY

Sensitive Period Indicators

Sensitive period indicator flows derived using the wetted perimeter method (CDFW 2020) are provided in Table 10 for Mark West Creek with site-specific field data. When the sensitive period indicator flows are not met, the ecosystem is likely to be particularly sensitive to additional flow reductions and other stressors (CDFW 2017).

In Table 10, there is one value for each reach, which applies across all months and years. The numbers next to each stream name correspond to the numbers on the Mark West Creek watershed map (Figure 2). Results presented here are the mean of results for all sites within a reach. The third column indicates the number of transects that were used to estimate the sensitive period indicator for that stream (see Appendix B for additional information about transect selection). The cross-channel transect profiles and wetted perimeter-discharge curves used in the analysis for each site are located in Appendix B.

Table 10. Sensitive Period Indicator flows (by drainage area).

Stream	Drainage Area (mi^2)	Number of Sites	Sensitive Period Indicators (cfs)
10) Mark West Creek 5	10.0	2	3
11) Mark West Creek 6	6.6	3	2
12) Mark West Creek 7	4.1	2	3

Mark West Creek
MARK WEST CREEK WATERSHED, SONOMA COUNTY

Salmonid Passage Flows

Juvenile steelhead passage flows are displayed in Table 11. These passage flows provide connectivity between mesohabitat units for juvenile steelhead. The numbers next to each stream name correspond to the numbers found on the Mark West Creek watershed map (Figure 2). The third column indicates the number of transects that were used to estimate the passage flow for that stream (see Appendix B for additional information about transect selection). The cross-channel transect profiles used in the analysis for each site are located in Appendix B.

Table 11. Juvenile steelhead passage flows (by drainage area).

Stream	Drainage Area (mi^2)	Number of Sites	Juvenile Steelhead Passage Flows (cfs)
10) Mark West Creek 5	10.0	2	6
11) Mark West Creek 6	6.6	3	3
12) Mark West Creek 7	4.1	2	4


Mark West Creek
MARK WEST CREEK WATERSHED, SONOMA COUNTY

Flow Criteria

Flow criteria provide a set of flow values that may be used to develop a flow regime for a location within a watershed. Using results from the Functional Flows section of this Watershed Criteria Report, flow criteria have been developed for Mark West Creek, Santa Rosa Creek, and Laguna de Santa Rosa. While the flow criteria presented in this section were developed for specific locations within the Mark West Creek watershed, patterns and timings of flows throughout the watershed are consistent, and a similar process to the one outlined below could be followed to develop criteria for other locations within the watershed. Flow criteria presented below are provided as a tool for consideration in water management planning. While criteria are not formal flow recommendations, they may be used to develop flow recommendations. These criteria should not be relied upon for legal compliance and do not ensure project success. The Department may revise instream flow criteria for Mark West Creek and its tributaries based upon any new scientific information that may become available.

Flow criteria were developed for six locations within the Mark West Creek watershed for three water year types (i.e., wet, moderate, dry) using functional flow results from Table 2–Table 7. These locations were selected to capture distinct areas throughout the watershed. In each case, criteria represent median functional flow metric values by water year type. Median values are commonly used to represent water availability in other instream flow methods, such as habitat duration time series analysis. Median flows would be met or exceeded in 50% of years under natural conditions, and represent a useful potential long-term management target. While medians were used to establish criteria, in the driest years flows may be closer to 10th percentile functional flow values, and in the wettest years may be closer to the 90th percentile values. In Table 12–Table 17, criteria are presented for each season corresponding to functional flow metrics, with additional detail provided during the spring to more specifically capture changes in flows during the transition period between the wet season and dry season. Note, the length of the spring recession varies by water year type.

Table 12. Flow criteria (in cfs) for Lower Mark West Creek (Mark West Creek 1). Criteria are provided for each functional flow season and are stratified by water year type.

Water Year Type	**Wet Season** Dec-Mar	**Spring Recession** Week 1	**Spring Recession** Week 2	**Spring Recession** Week 3	**Spring Recession** Week 4	**Spring Recession** Week 5	**Spring Recession** Week 6	**Spring Recession** Week 7	**Spring Recession** Week 8	**Dry Season** Jun-Dec
Wet	144†	445	265	158	94	56	33	20	15	15‡
Moderate	87†	259	154	92	55	33	19	12	-	11‡
Dry	43†	133	79	47	28	17	10	6	-	5‡

† Approximately every two years, allow one to five peak flow events of 7,840 cfs. Approximately every five years, allow one to three peak flow events of 10,600 cfs.

‡ In October, allow fall pulse events of 226 cfs in wet years, 159 cfs in moderate years, and 135 cfs in dry years.

- The length of the recession varies by water year type. In wet years, the recession lasts for eight weeks, in moderate years, the recession lasts for seven weeks, and in dry years, it lasts for seven weeks.

Table 13. Flow criteria (in cfs) for Middle Mark West Creek (Mark West Creek 3). Criteria are provided for each functional flow season and are stratified by water year type.

Water Year Type	**Wet Season** Dec-Mar	**Spring Recession** Week 1	**Spring Recession** Week 2	**Spring Recession** Week 3	**Spring Recession** Week 4	**Spring Recession** Week 5	**Spring Recession** Week 6	**Spring Recession** Week 7	**Spring Recession** Week 8	**Dry Season** Jun-Dec
Wet	34†	116	71	44	27	17	10	6	4	4‡
Moderate	19†	59	36	22	14	9	5	3	-	3‡
Dry	10†	28	17	11	7	4	2	2	-	2‡

† Approximately every two years, allow one to five peak flow events of 1,360 cfs. Approximately every five years, allow one to two peak flow events of 1,960 cfs.

‡ In October, allow fall pulse events of 39 cfs in wet years, 22 cfs in moderate years, and 18 cfs in dry years.

- The length of the recession varies by water year type. In wet years, the recession lasts for eight weeks, in moderate years, the recession lasts for seven weeks, and in dry years, it lasts for seven weeks.

Table 14. Flow criteria (in cfs) for Upper Mark West Creek (Mark West Creek 5). Criteria are provided for each functional flow season and are stratified by water year type.

Water Year Type	**Wet Season** Dec-Mar	**Spring Recession** Week 1	**Spring Recession** Week 2	**Spring Recession** Week 3	**Spring Recession** Week 4	**Spring Recession** Week 5	**Spring Recession** Week 6	**Spring Recession** Week 7	**Dry Season** Jun-Dec
Wet	11†	36	22	14	8	5	3	2	1‡
Moderate	6†	17	11	7	4	2	2	-	1‡
Dry	3†	9	6	3	2	1	1	-	1‡

† Approximately every two years, allow one to five peak flow events of 327 cfs. Approximately every five years, allow one to two peak flow events of 539 cfs.

‡ In October, allow fall pulse events of 15 cfs in wet years, seven cfs in moderate years, and five cfs in dry years.

- The length of the recession varies by water year type. In wet years, the recession lasts for seven weeks, in moderate years, the recession lasts for six weeks, and in dry years, it lasts for six weeks.

Table 15. Flow criteria (in cfs) for Lower Santa Rosa Creek (Santa Rosa Creek 2). Criteria are provided for each functional flow season and are stratified by water year type.

Water Year Type	**Wet Season** Dec-Mar	**Spring Recession** Week 1	**Spring Recession** Week 2	**Spring Recession** Week 3	**Spring Recession** Week 4	**Spring Recession** Week 5	**Spring Recession** Week 6	**Spring Recession** Week 7	**Dry Season** Jun-Dec
Wet	45†	128	76	45	27	16	10	6	4‡
Moderate	24†	73	43	26	15	9	5	-	3‡
Dry	12†	33	20	12	7	4	-	-	2‡

† Approximately every two years, allow one to five peak flow events of 2,230 cfs. Approximately every five years, allow one to three peak flow events of 3,040 cfs.

‡ In October, allow fall pulse events of 51 cfs in wet years, 36 cfs in moderate years, and 31 cfs in dry years.

- The length of the recession varies by water year type. In wet years, the recession lasts for seven weeks, in moderate years, the recession lasts for six weeks, and in dry years, it lasts for five weeks.

Table 16. Flow criteria (in cfs) for Upper Santa Rosa Creek (Santa Rosa Creek 3). Criteria are provided for each functional flow season and are stratified by water year type.

Water Year Type	**Wet Season** Dec-Mar	**Spring Recession** Week 1	**Spring Recession** Week 2	**Spring Recession** Week 3	**Spring Recession** Week 4	**Spring Recession** Week 5	**Spring Recession** Week 6	**Spring Recession** Week 7	**Dry Season** Jun-Oct
Wet	13†	41	25	16	10	6	4	2	1‡
Moderate	7†	22	14	8	5	3	2	-	1‡
Dry	3†	10	6	4	2	1	-	-	<1‡

† Approximately every two years, allow one to five peak flow events of 610 cfs. Approximately every five years, allow one to two peak flow events of 759 cfs.

‡ In October, allow fall pulse events of 17 cfs in wet years, eight cfs in moderate years, and six cfs in dry years.

- The length of the recession varies by water year type. In wet years, the recession lasts for seven weeks, in moderate years, the recession lasts for six weeks, and in dry years, it lasts for five weeks.

Table 17. Flow criteria (in cfs) for Laguna de Santa Rosa (Laguna de Santa Rosa 1). Criteria are provided for each functional flow season and are stratified by water year type.

Water Year Type	**Wet Season** Dec-Mar	**Spring Recession** Week 1	**Spring Recession** Week 2	**Spring Recession** Week 3	**Spring Recession** Week 4	**Spring Recession** Week 5	**Spring Recession** Week 6	**Spring Recession** Week 7	**Dry Season** Jun-Oct
Wet	35†	107	64	38	23	13	8	5	4‡
Moderate	19†	63	38	22	13	8	5	3	2‡
Dry	8†	23	14	8	5	3	2	-	1‡

† Approximately every two years, allow one to five peak flow events of 928 cfs. Approximately every five years, allow one to three peak flow events of 2,310 cfs.

‡ In October, allow fall pulse events of 65 cfs in wet years, 46 cfs in moderate years, and 36 cfs in dry years.

- The length of the recession varies by water year type. In wet years, the recession lasts for seven weeks, in moderate years, the recession lasts for seven weeks, and in dry years, it lasts for six weeks.

The timing of the wet season was approximated using the median start dates for each water year type (i.e., wet, moderate, dry) using functional flow results from Table 2–Table 7. The wet-season baseflow magnitudes represent flows between storm events; however, following peak flow events (e.g., winter storms), flows should be much higher than the criteria presented in Table 12–Table 17. Additionally, 2- and 5-year peak flow events, respectively, should be allowed to pass through the watershed. Refer to Table 2–Table 7 for specific recommended frequencies and durations of these peak events for each water year type. The end of the wet season for each water year type was determined by the median start date of the spring recession.

The median wet-season flow magnitude was used to represent spring high flows that immediately precede the recession period. This metric represents an elevated flow relative to baseflows occurring early in the wet season, as storm events saturate the system by the spring. The median spring recession rate for each water year type was used to calculate a daily decrease in flows, which were then averaged by week for the duration of the recession. The duration of the recession was determined by applying a daily rate of change in flows until the median dry-season baseflow magnitude was reached. The length of the recession varies across water year types due to differences in start magnitudes, rates of change, and the magnitude of dry-season baseflows.

The dry-season baseflow magnitude was used to establish flow criteria for the dry season. Baseflows will likely be higher at the beginning of the dry season than at the end of the dry season, but the median flow over the entire dry season should match the listed criteria. Additionally, fall pulse events should occur annually in October. Specific magnitudes and durations by water year type for the fall pulse flows can be found in Table 2–Table 7. The end of the dry season for each water year type was determined by the median start date of the wet season.

Acknowledgements

Thank you to the following Department Water Branch staff for their assistance with this report: Trevor Gandell and Lillian McDougall.

The data used in this report were collected with assistance from the following Department Water Branch staff: James Allen, Todd Carlin, Hanna Casares, William Cowan, Danielle Elledge, Lanette Richardson, and Paige Uttley.

Mark West Creek
MARK WEST CREEK WATERSHED, SONOMA COUNTY

References

Ackerly, D. (2018). San Francisco Bay Area region report. California's Fourth Climate Change Assessment. CCCA4-SUM-2018-005.

Annear, T., I. Chisholm, H. Beecher, A. Locke, P. Aarrestad, C. Coomer, C. Estes, J. Hunt, R. Jacobson, G. Jobsis, J. Kauffman, J. Marshall, K. Mayes, G. Smith, R. Wentworth and C. Stalnaker (2004). Instream flows for riverine resource stewardship. Revised edition. Instream Flow Council, Cheyenne, WY.

Carlin, T., W. Cowan, B. Stanford, J. Allen and N. Gephart (in prep.). Instream flow evaluation: Juvenile rearing of steelhead and Coho Salmon in upper Mark West Creek, Sonoma County. California Department of Fish and Wildlife, Instream Flow Program (CDFW), West Sacramento, CA. Stream evaluation report 2022-01.

CDFG (2004). Recovery strategy for California Coho Salmon. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch (CDFG), Sacramento, CA. Available: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=99401.

CDFW (2017). Low-flow threshold fact sheet. California Department of Fish and Wildlife, Instream Flow Program (CDFW), Sacramento, CA. Available: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=139778&inline.

CDFW (2018a). Study plan habitat and instream flow evaluation for anadromous steelhead and Coho Salmon in upper Mark West Creek, Sonoma County. California Department of Fish and Wildlife, Instream Flow Program (CDFW), Sacramento, CA.

CDFW (2018b). Standard operating procedure for the habitat retention method in California. California Department of Fish and Wildlife, Instream Flow Program (CDFW), Sacramento, CA. CDFW-IFP-006, version 2. Available: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=128310.

CDFW (2020). Standard operating procedure for the wetted perimeter method in California. California Department of Fish and Wildlife, Instream Flow Program (CDFW), West Sacramento, CA. CDFW-IFP-004, version 3. Available: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=74182.

CDFW (2021). Overview of watershed-wide instream flow criteria report methodology, Version 2. California Department of Fish and Wildlife, Instream Flow Program (CDFW), West Sacramento, CA. Available: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=177832&inline.

CDFW (2022). Watershed-wide instream flow criteria webpage. California Department of Fish and Wildlife, Instream Flow Program (CDFW), West Sacramento, CA. Available: https://wildlife.ca.gov/Conservation/Watersheds/Instream-Flow/Watershed-Criteria.

CEFWG (2021). California Natural Flows Database: Functional flow metrics v1.2.1. California Environmental Flows Working Group (CEFWG). Available: https://rivers.codefornature.org. Accessed: August 2021.

CNRA, CDFA and CalEPA (2016). California Water Action Plan 2016 update, California Natural Resources Agency, California Department of Food and Agriculture (CDFA), and California Environmental Protection Agency (CalEPA), Sacramento, CA.

Hatfield, T. and J. Bruce (2000). Predicting salmonid habitat-flow relationships for streams from western North America. North American Journal of Fisheries Management 20: 1005-1015.

Jowett, I. G., T. Payne and R. Milhous (2017). System for Environmental Flow Analysis, software manual, version 1.4. Arcata, CA, Aquatic Habitat Analysts Inc.

Rodríguez-Iturbe, I. and J. B. Valdés (1979). The geomorphic structure of hydrologic response. Water Resources Research 15(6): 1409-1420.

Shannon, C. and T. Christy (2012). Winter steelhead distribution [ds340]. California Department of Fish and Game (CDFG), Biogeographic Information and Observation System (BIOS). Available: https://wildlife.ca.gov/Data/BIOS.

Tessmann, S. A. (1980). Environmental assessment, technical appendix E, Reconnaissance elements of the western Dakotas region of South Dakota study. South Dakota State University, Water Resources Research Institute, Brookings, SD.

USEPA and USGS (2012). National Hydrography Dataset Plus (NHDPlus) medium resolution version 2.10. U.S. Environmental Protection Agency (USEPA) and the U.S. Geological Survey (USGS).

USFWS (1994). Using the computer based Physical Habitat Simulation System (PHABSIM). U.S. Fish and Wildlife Service (USFWS).

USGS (2022). National Water Information System data available on the World Wide Web (USGS Water Data for the Nation). U.S. Geological Survey (USGS). Available: http://waterdata.usgs.gov/nwis/. Accessed: January 1, 2022.

Zimmerman, J. K. H., D. M. Carlisle, J. T. May, K. R. Klausmeyer, T. E. Grantham, L. R. Brown and J. K. Howard (2021). California Unimpaired Flows Database v2.1.0. The Nature Conservancy, San Francisco, CA. Available: https://flowline.codefornature.org/.

Mailing address:
California Department of Fish and Wildlife, P.O. Box 944209, Sacramento CA 94244-2090

All photos in this document were taken by Department Staff. Cover photos are all from Mark West Creek, Sonoma County.

Appendix A
Reach Definition

Table A-1 presents each reach analyzed in this report with the associated NHDPlus COMIDs. The stream reaches were delineated using NHDPlus Version 2 medium-resolution mapping (USEPA and USGS 2012). The COMIDs were used to identify and download natural flow estimates for each selected reach.

Table A-1. Reach delineation.

Stream	COMID
1) Mark West Creek 1	8273161
2) Windsor Creek 1	8273153
3) Pool Creek	8272483
4) Windsor Creek 2	8272481
5) Mark West Creek 2	8273193
6) Mark West Creek 3	8272529
7) Porter Creek	8272451
8) Mark West Creek 4	8272443
9) Humbug Creek	8272489
10) Mark West Creek 5	8272525
11) Mark West Creek 6	8272511
12) Mark West Creek 7	8272499
13) Santa Rosa Creek 1	8273639
14) Santa Rosa Creek 2	8273645
15) Rincon Creek	8273235
16) Tributary 1	8273633
17) Santa Rosa Creek 3	8273229
18) Santa Rosa Creek 4	8273173
19) Salt Creek	8273159
20) Santa Rosa Creek 5	8272509
21) Laguna de Santa Rosa 1	8273651
22) Blucher Creek	8273407
23) Laguna de Santa Rosa 2	8273659
24) Tributary 2	8273403
25) Laguna de Santa Rosa 3	8273425

Appendix B
Supplemental Information

This appendix provides additional details on data used to generate results included in the Watershed-Wide Instream Flow Criteria for Mark West Creek report (Watershed Criteria Report). Field data collected in the Mark West Creek watershed were used to develop sensitive period indicator flows, using the wetted perimeter method, and steelhead passage flows, using the habitat retention method. Data collection procedures are described in the Standard Operating Procedure for the Wetted Perimeter Method in California (CDFW 2020) and the Standard Operating Procedure for the Habitat Retention Method in California (CDFW 2018b).

To develop sensitive period indicator flows, data were collected at seven transects in the Mark West Creek watershed following the standard wetted perimeter method (CDFW 2020).

Seven transects within the Mark West Creek watershed were used to develop steelhead passage flows using the habitat retention method (CDFW 2018b).

The field sites 2HRMQ in Mark West Creek 6 and 3HRM1 in Mark West Creek 7 were derived from an alternative method using hydraulic outputs from a two-dimensional (2D) model developed by the Department. In a separate study, 2D models were developed for three representative reaches to estimate salmonid juvenile rearing in upper Mark West Creek (CDFW 2018a). These three reaches overlap with the three reaches where field sites are located within the Watershed Criteria Report (Mark West Creek 5, Mark West Creek 6, and Mark West Creek 7). The 2D module of the hydraulic modeling program HEC-RAS (2018) was used to define straight transects within the boundary of the model area. Staff selected transects across a hydraulic control within the 2D model area in Mark West Creek 6, creating field site 2HRMQ, and Mark West Creek 7, creating field site 3HRM1. For site 2HRMQ, the 2D model predicted water surface elevations over a range of distinct flows to create a synthetic rating curve at the transect. The stream channel profile data of the selected transect and the synthetic rating curve were imported into the program System for Environmental Flow Assessment (SEFA; Jowett et al. 2017). The SEFA allows the user to model straight hydraulic transects and output the data required to compute HRM and WPM results.

Data were collected for some additional sites but were omitted from analysis either because they were outside the modelable range, were located on a non-representative transect, or because the survey did not capture bankfull stage. Sites omitted and the rationale for each omission are documented in the Quality Assurance and Quality Control log stored at the Department Headquarters office. Table B-1 lists the sites included the sensitive period indicators and steelhead passage flows analyses.

Table B-1. Summary of sites included in the final analysis. X indicates the site was included in the analysis; - indicates sites removed from analysis, * indicates site developed using 2D model.

Stream	Riffle Transect	Sensitive Period Indicator	Juvenile Steelhead Passage
10) Mark West Creek 5	1HRM1	X	X
10) Mark West Creek 5	1HRM2	X	X
10) Mark West Creek 5	1HRM3	-	-
11) Mark West Creek 6	2HRMD	X	X
11) Mark West Creek 6	2HRMQ*	X	X
11) Mark West Creek 6	2HRMU	X	X
12) Mark West Creek 7	3HRM1*	X	X
12) Mark West Creek 7	3HRM2	-	-
12) Mark West Creek 7	3HRM3	X	X

Table B-2 presents the hydraulic model calibration results for transects included in the analysis. Differences between measured and modeled water surface elevation (WSEL) estimates for all sites were within the USFWS (1994) physical habitat simulation guidelines of 0.10 ft. Table B-3 presents the 2D model results for the field sites 2HRMQ and 3HRM1.

Table B-2. Hydraulic model calibration results by transect.

Stream	Riffle Transect	Survey Flow Calibration Measurement (cfs)	Field Measured WSEL (ft)	HydroCalc Predicted WSEL (ft)	Difference (+/-)
10) Mark West Creek 5	1HRM1	4.0	98.49	98.50	0.01
10) Mark West Creek 5	1HRM2	4.0	696.93	696.94	0.01
11) Mark West Creek 6	2HRMD	1.6	97.37	97.38	0.01
11) Mark West Creek 6	2HRMU	1.6	95.96	95.97	0.01
12) Mark West Creek 7	3HRM3	3.2	97.81	97.82	0.01

Table B-3. The 2D model results for the field sites 2HRMQ and 3HRM1.

Stream	Riffle Transect	Survey Flow Calibration Measurement (cfs)	Field Measured WSEL (ft)	HydroCalc Predicted WSEL (ft)	Difference (+/-)
11) Mark West Creek 6	2HRMQ	20	891.19	891.19	0.00
12) Mark West Creek 7	3HRM1	1.3	1015.71	1015.72	0.01

The wetted perimeter method requires generation of a graphical plot showing the relationship between wetted perimeter and discharge. The breakpoint is identified where the greatest change in slope occurs in the channel cross section. The sensitive period indicator for each transect is determined by 1) visually identifying the lowest discharge associated with a breakpoint on the plot and 2) estimating the discharge at which a specified percentage of the bankfull channel perimeter is wetted (Annear et al. 2004; CDFW 2020). The sensitive period indicator is the larger of these two discharges. For streams up to 50 ft wide, 50% of the bankfull channel perimeter must be wetted; for streams 50–60 ft wide, 60% of the bankfull channel perimeter must be wetted.

The habitat retention method identifies flows that permit salmonid passage across constriction points in the stream channel. Both species- and life-stage-specific mean depth criteria and either velocity or wetted perimeter criteria must be met. Transect cross sections with the sensitive period indicator and steelhead passage flow WSELs and wetted perimeter-discharge curves are provided in Figures B-1 to B-14.

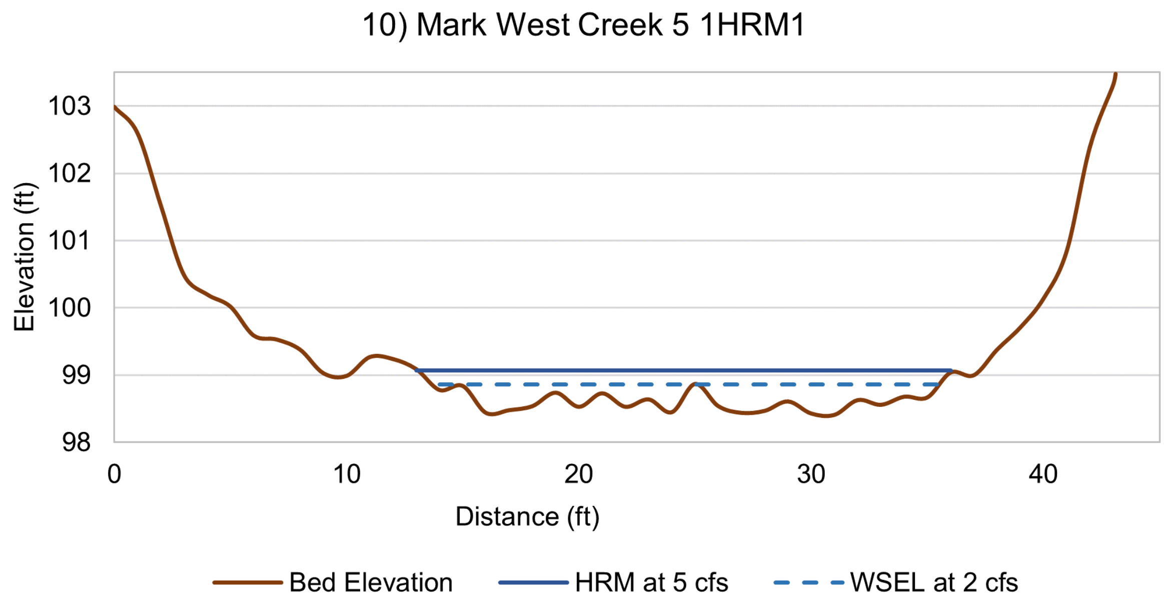


Figure B-1. Mark West Creek 1HRM1 transect cross section with bed elevation, WPM WSEL, and HRM WSEL.

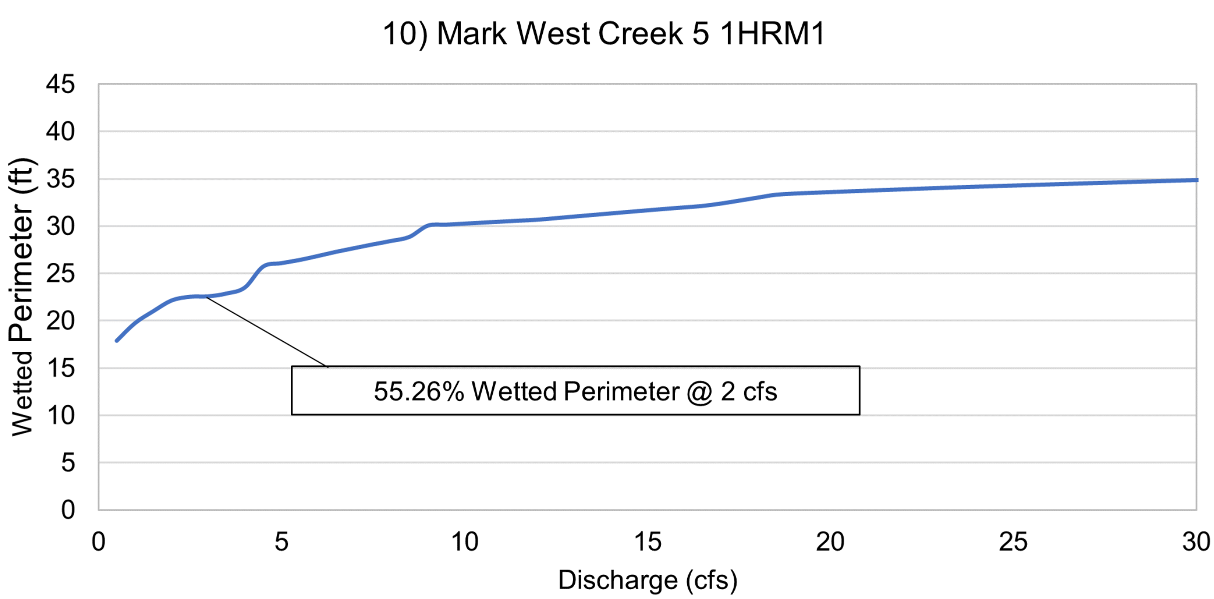


Figure B-2. Mark West Creek HRM1 transect wetted perimeter-discharge curve.

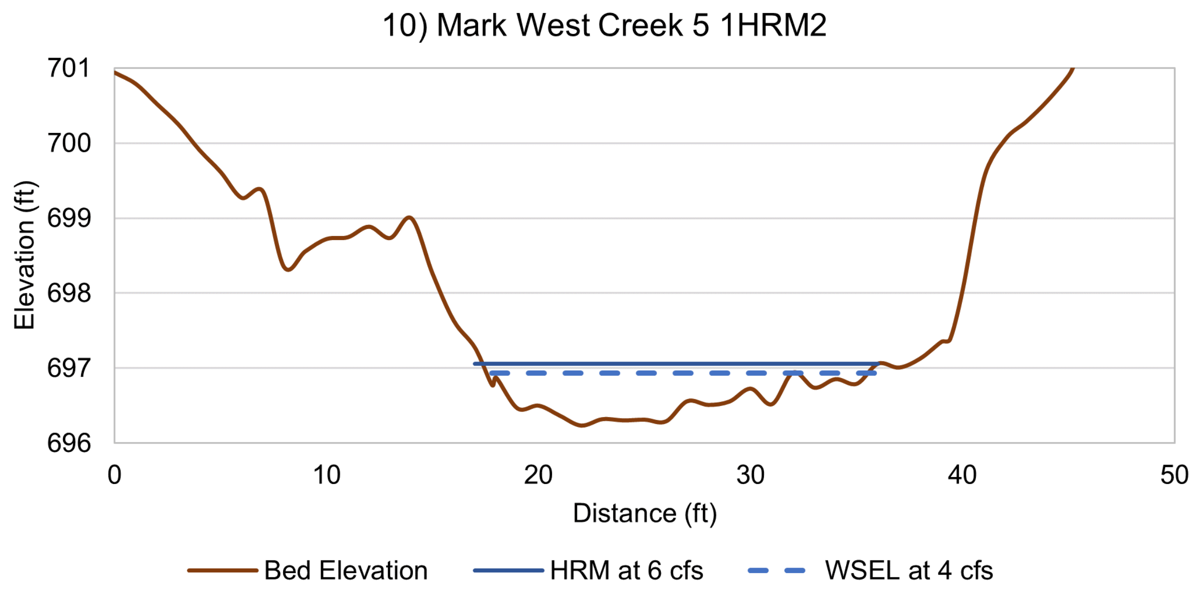


Figure B-3. Mark West Creek 1HRM2 transect cross section with bed elevation, WPM WSEL, and HRM WSEL.

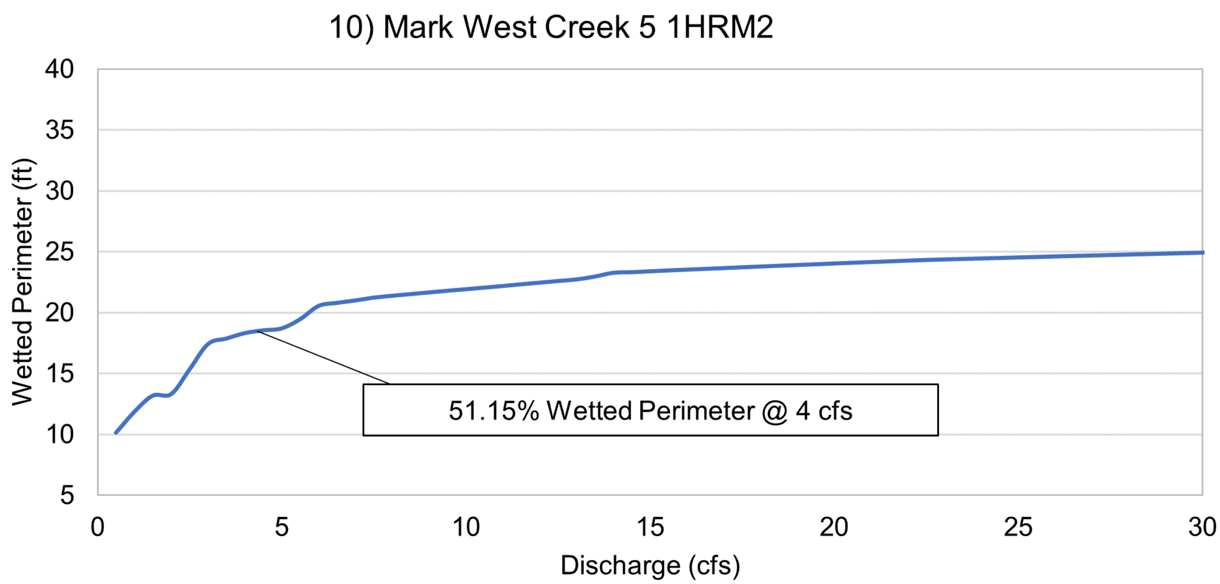


Figure B-4. Mark West Creek 1HRM2 transect wetted perimeter-discharge curve.

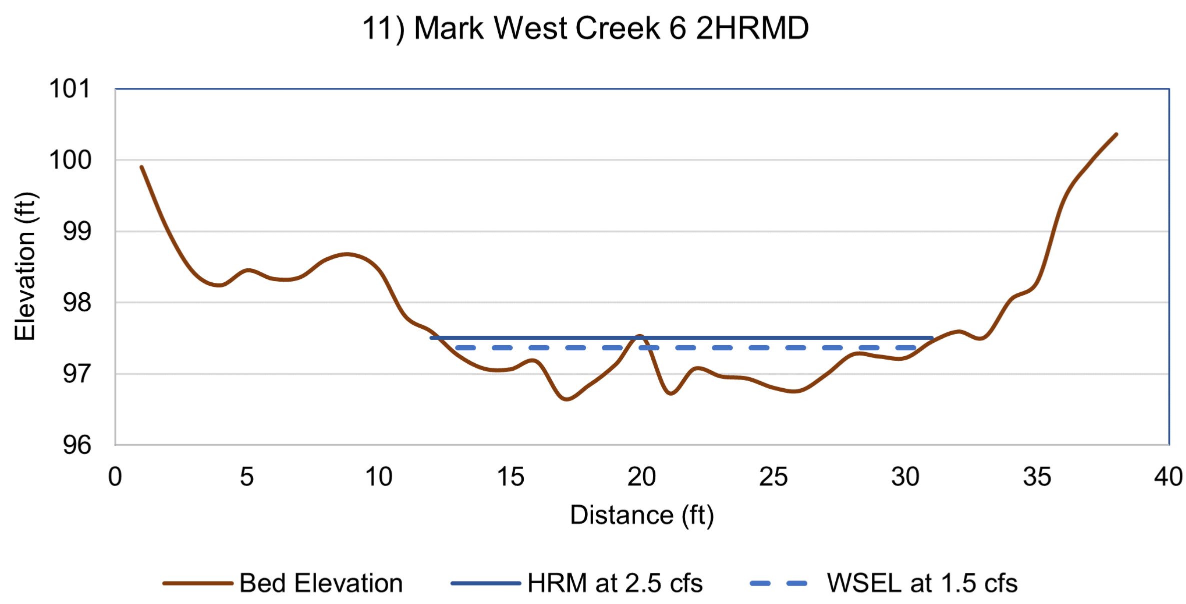


Figure B-5. Mark West Creek 2HRMD transect cross section with bed elevation, WPM WSEL, and HRM WSEL.

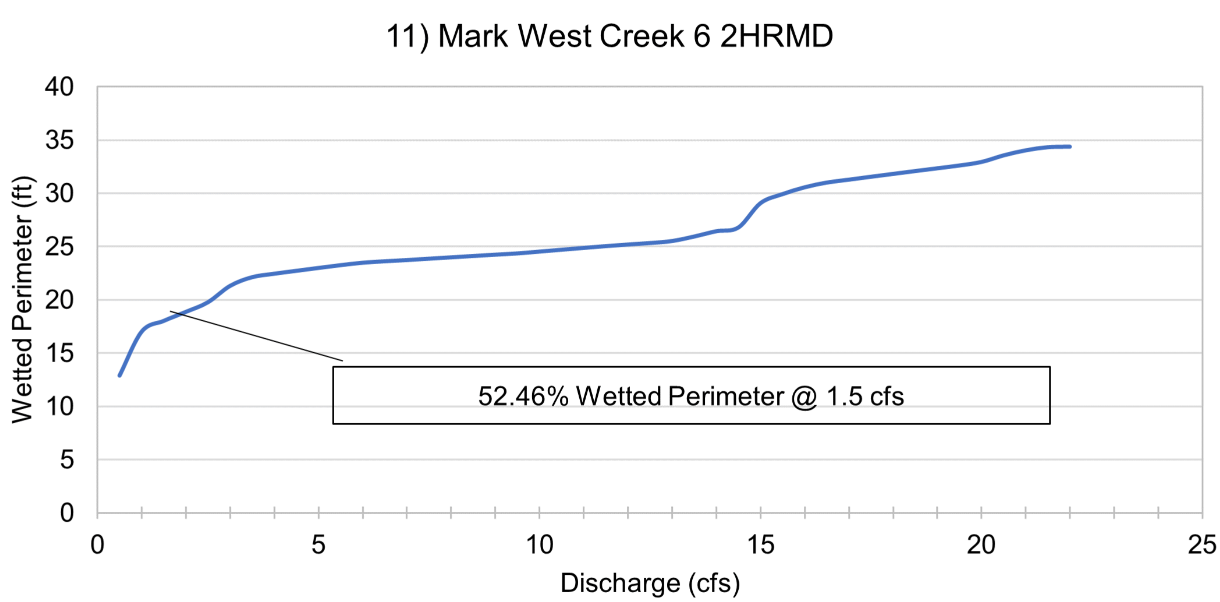


Figure B-6. Mark West Creek 2HRMD transect wetted perimeter-discharge curve.

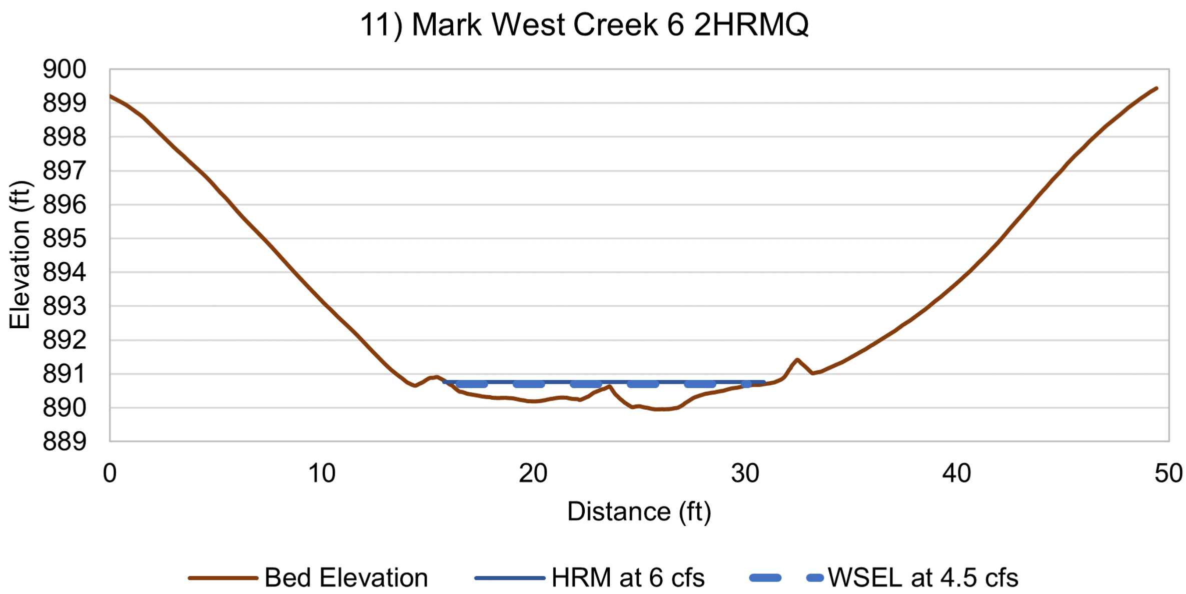


Figure B-7. Mark West Creek 2HRMQ transect cross section with bed elevation, WPM WSEL, and HRM WSEL.

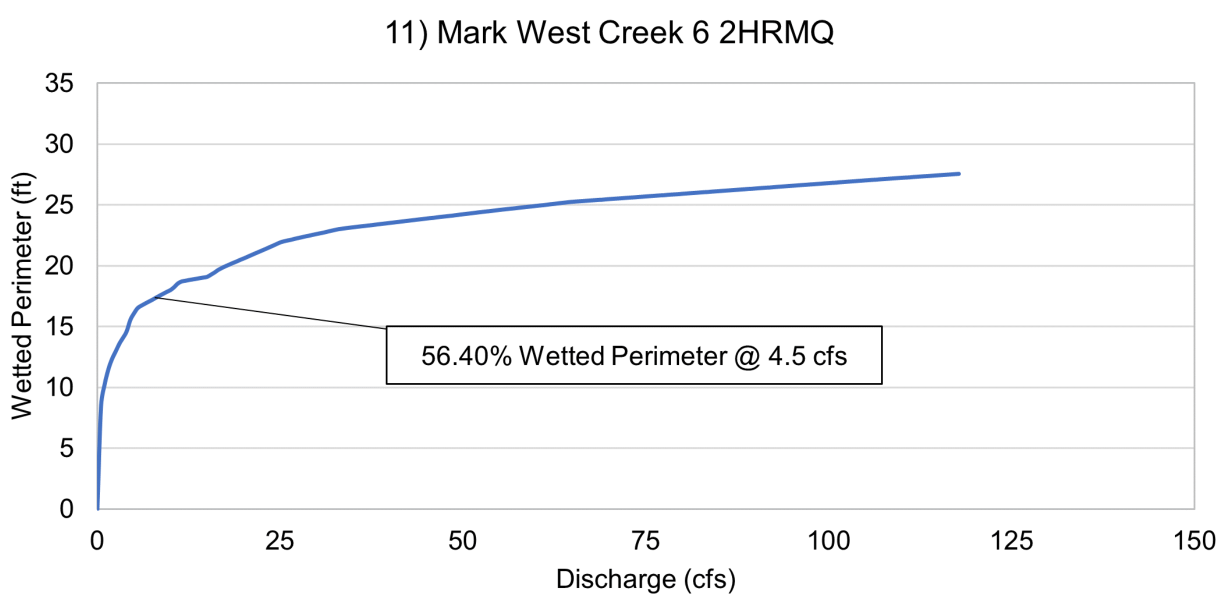


Figure B-8. Mark West Creek 2HRMQ transect wetted perimeter-discharge curve.

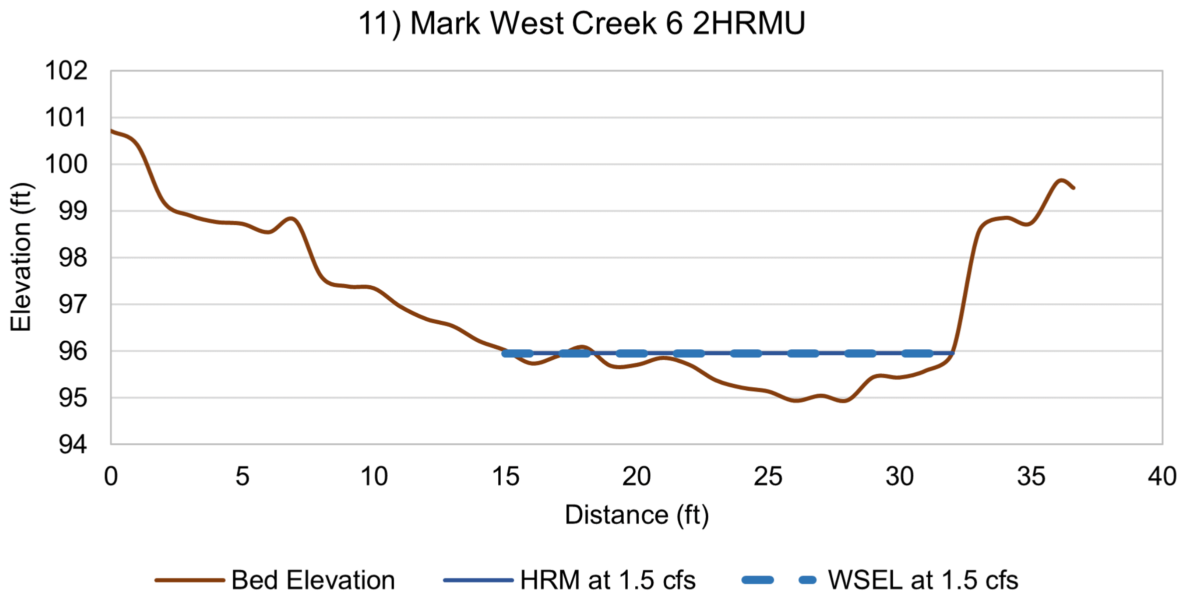


Figure B-9. Mark West Creek 2HRMU transect cross section with bed elevation, WPM WSEL, and HRM WSEL.

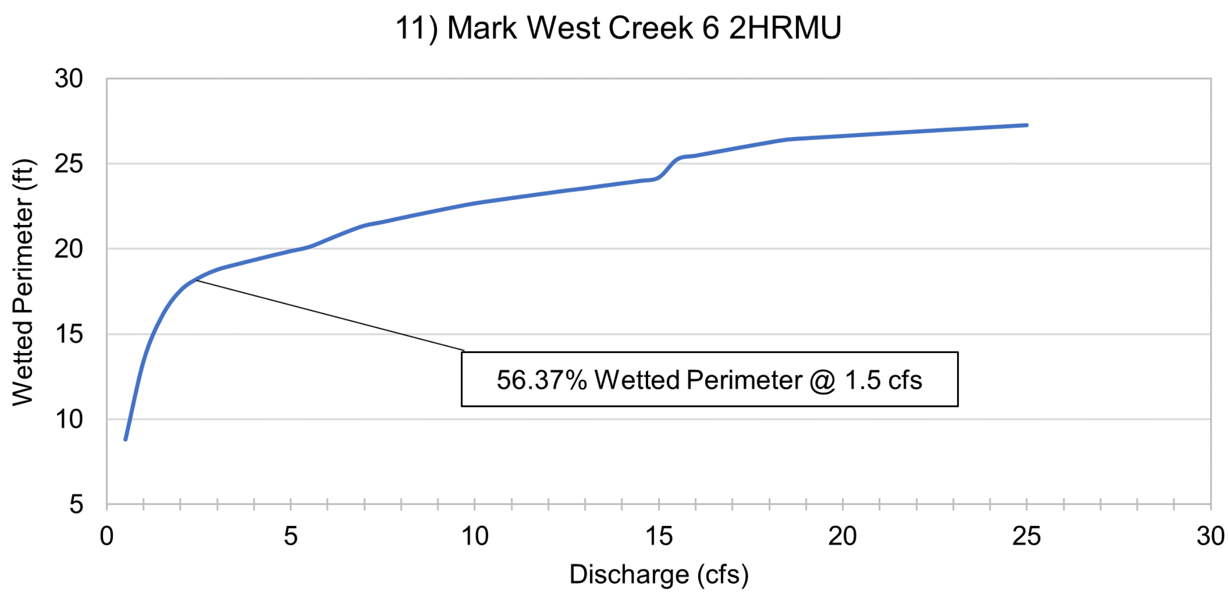


Figure B-10. Mark West Creek 2HRMU transect wetted perimeter-discharge curve.

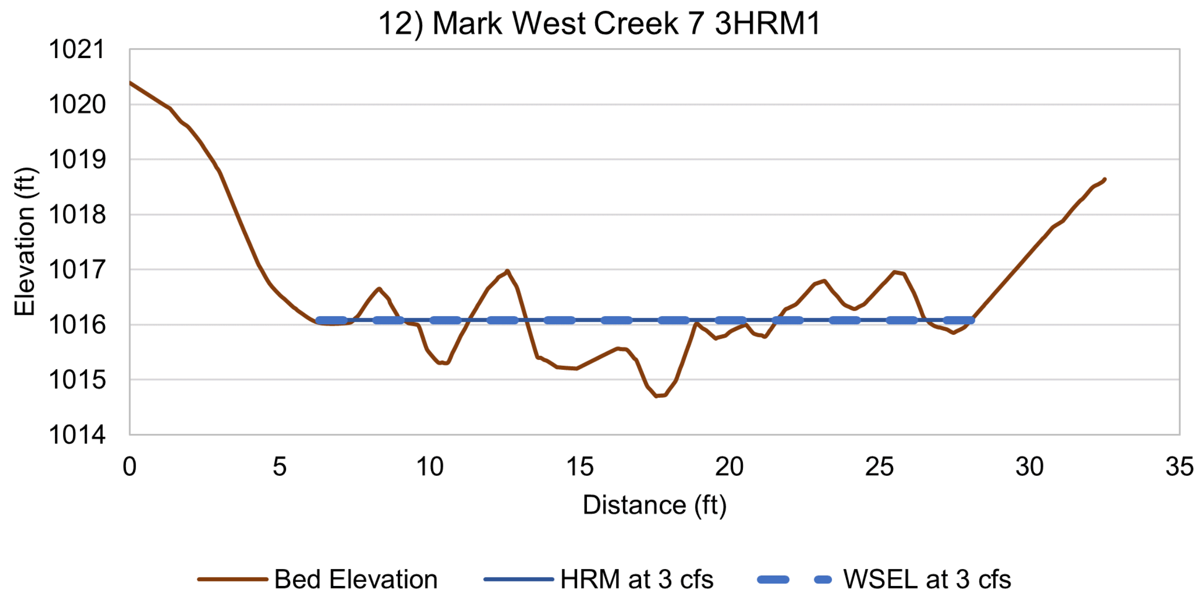


Figure B-11. Mark West Creek 3HRM1 transect cross section with bed elevation, WPM WSEL, and HRM WSEL.

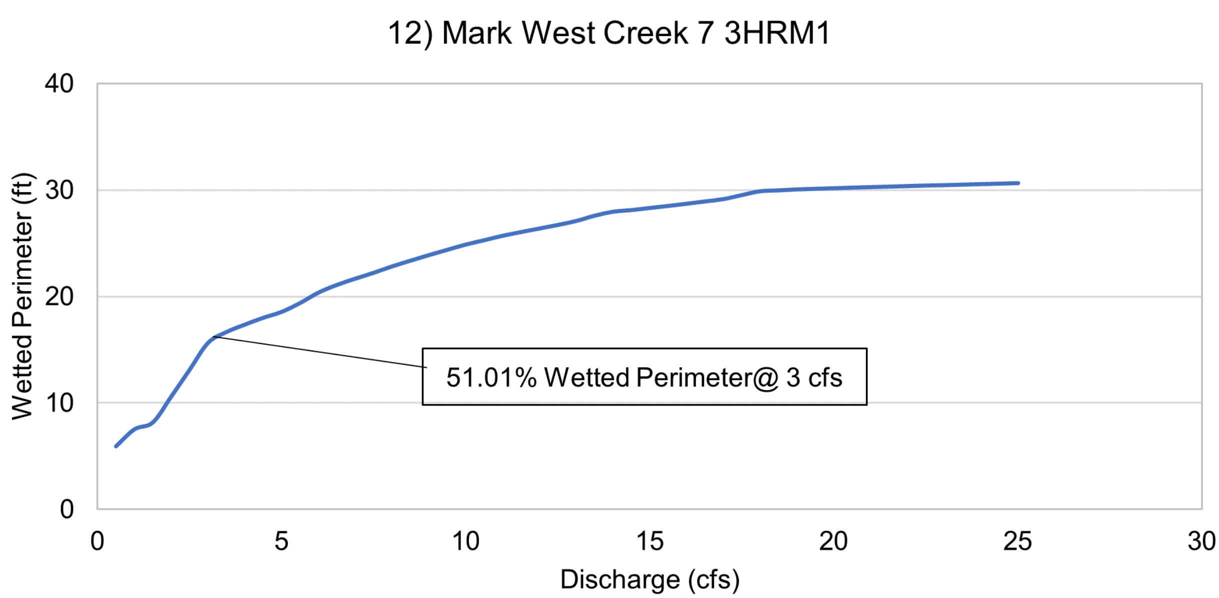


Figure B-12. Mark West Creek 3HRM1 transect wetted perimeter-discharge curve.

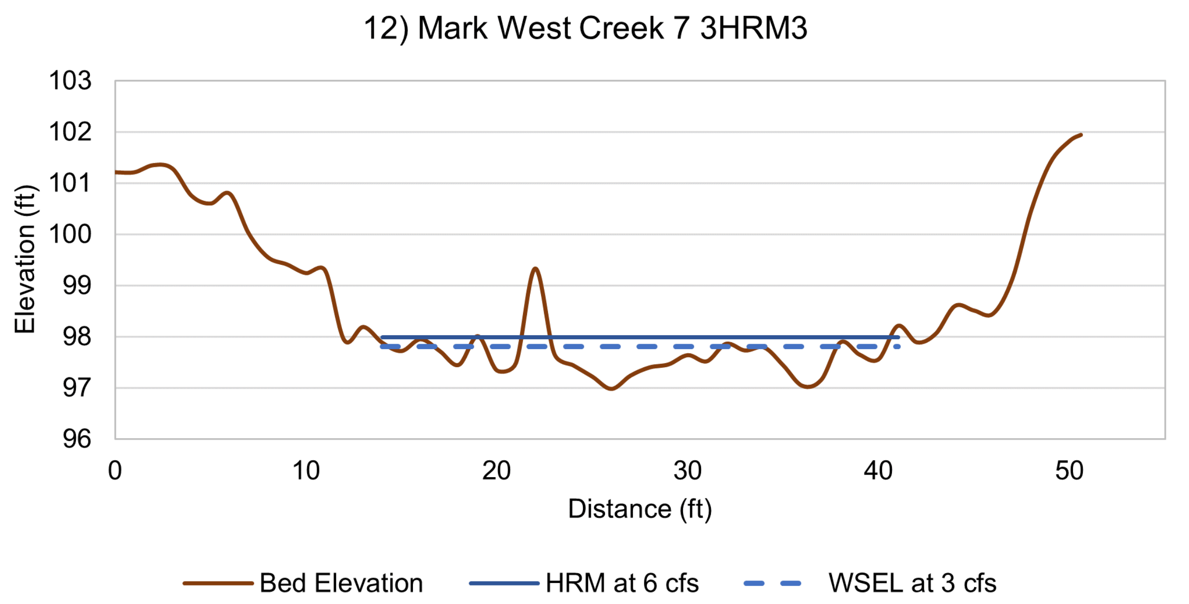


Figure B-13. Mark West Creek 3HRM3 transect cross section with bed elevation, WPM WSEL, and HRM WSEL.

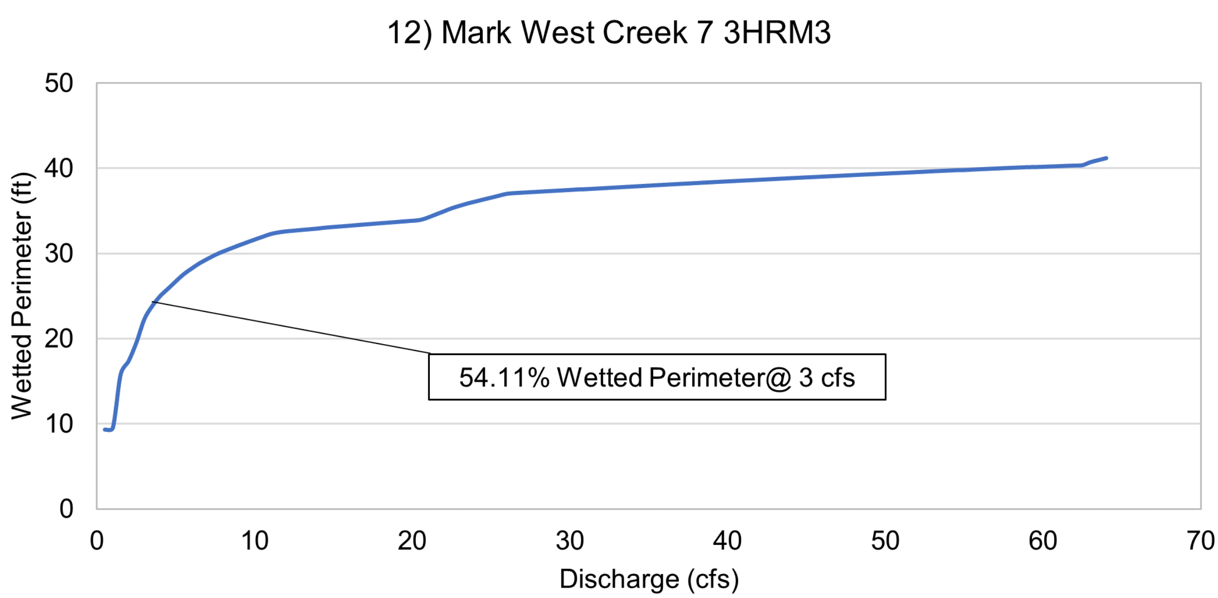


Figure B-14. Mark West Creek 3HRM3 transect wetted perimeter-discharge curve.