McBain Associates
APPLIED RIVER SCIENCES
980 7th Street, Arcata, CA 95521 · PO Box 663, Arcata, CA 95518 · ph (707) 826-7794 · fax (707)826-7795

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APPENDIX G: 1-D AND 2-D MODELING TIME-SERIES ANALYSIS METHODS AND RESULTS – DRAFT

Prepared for: *Darren Mierau*
California Trout
615 11th Street
Arcata, CA 95521

Prepared by: *McBain Associates*
980 7th Street
Arcata, CA 95521

1 INTRODUCTION

This memorandum is an appendix to the *Sproul Creek Site Specific Instream Flow Study* (main report). This appendix describes the time-series analysis methodology and results used to compute median habitat index values for freshwater life stages of Coho Salmon (*Oncorhynchus kisutch)*, steelhead (*O. mykiss),* Chinook Salmon adult spawning (*O. tshawytscha*), and productive benthic macroinvertebrates habitat (productive BMI) in Sproul Creek, tributary to the South Fork Eel River. This time-series analysis is based on daily average unimpaired streamflows estimated for two hydraulic model study reaches in Sproul Creek: at the Upper South Fork Sproul Creek (USF) study reach, and at the Upper Mainstem Sproul Creek (UMS) study reach. The time-series analysis computes median habitat index values for each calendar month, for five equally weighted water year (WY) classes (i.e., Extremely Wet, Wet, Normal, Dry, and Extremely Dry).

The time-series analysis methodology in this appendix is intended to follow the analytical methods recommended by the CA Department of Fish and Wildlife Instream Flow Program protocols. (CDFW 2014). According to the Department's documentation:

> The Department's policy is that the federal Instream Flow Incremental Methodology (IFIM) will be used to evaluate and develop instream flow criteria and recommendations for projects which may affect the state's aquatic resources. The policy indicates that the IFIM approach will be used to assess the relationship between flows and habitat because of its benefits and defensibility.

Within the IFIM, many analytical approaches have been developed and utilized in instream flow studies in the past. The analytical approach selected for the Sproul Creek study follows the Department's approach used in the Big Sur River Instream Flow Evaluation Study (Holmes et al. 2014), because that study represents the most recent study completed by the Department in a coastal California, rainfall-dominated watershed. The Big Sur Instream Flow Evaluation summarized the time-series analysis as follows:

> [T]he habitat index vs discharge relationships for each lifestage were used to calculate monthly median habitat duration analyses and habitat time series (CDFW 2008b) based upon the monthly water types. Monthly habitat duration

values were determined by computing daily habitat index (WUA) values by monthly water type and steelhead lifestage, then by conducting a habitat duration analysis which included calculating a median habitat index for each water month and steelhead lifestage. Using the monthly water type and habitat index results ensures corresponding flow criteria and recommendations are consistent with natural water availability.

This approach is meant to identify median habitat index values for each salmonid species and life stage independently (i.e., spawning, fry, juvenile) throughout the year, based on habitat index vs discharge relationships developed in 1-D and 2-D physical habitat simulation modeling. *Instream Flow Criteria* are then selected for each life stage based on the most sensitive species' flow needs, integrated with other hydraulic habitat flow methodologies (e.g., fish passage flows). The time-series analysis uses annual unimpaired hydrographs along with the habitat index vs discharge relationships (WUA curves) to quantify available habitat throughout the year. WUA curves are developed from habitat suitability indices (HSI) selected for target species and life stages, combined with water depth and velocity outputs over a range of streamflows produced by either 1-dimensional (1-D) or 2-dimensional (2-D) hydraulic models.

Detailed descriptions of the 1-D and 2-D physical habitat simulation modeling used to develop habitat index vs discharge relationships are found in Appendices E and F, respectively.

1.1 Target Species and Life Stages

The goal of the *Sproul Creek Site Specific Instream Flow Study* is to develop instream flow criteria for priority species and life stages of salmonids in the Sproul Creek watershed using empirical and modeling methods recommended by the California Department of Fish and Wildlife Instream Flow Program. The study focuses on six primary life stages for the three salmonid species: (1) adult passage, (2) adult spawning, (3) young-of-year or "fry" rearing, (4) juvenile rearing and foraging, (5) juvenile passage, and (6) productive benthic invertebrate habitat. Coho Salmon and steelhead were identified as priority species because of their dependence on habitat in the Sproul Creek watershed for the majority of their freshwater life stages (Figure G-1). Chinook Salmon also spawn in Sproul Creek, and while juvenile Chinook Salmon may occasionally over-summer, most migrate to the Pacific Ocean by mid-to-late spring. Establishing habitat index values for the study reaches based on the needs of Chinook Salmon adult spawning habitat is therefore also an objective.

The freshwater life stages of the target species are strongly linked to the hydraulic characteristics and morphology of small gravel and cobble bed streams – particularly the hydraulics of the riffle–pool sequences that provide spawning habitat for adult salmonids, as well as food production and rearing habitat for juveniles. Water diversions can affect each stage of freshwater life history for Coho Salmon and steelhead, as well as adult Chinook Salmon spawning.

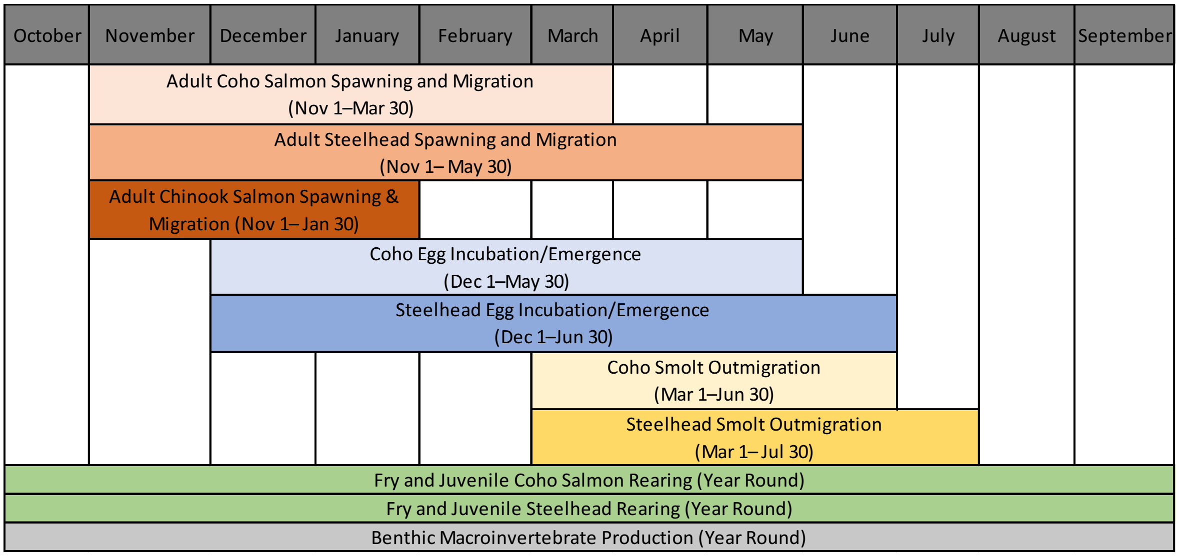


Figure G-1. Timing and duration of target species and life stages in the Sproul Creek watershed derived from Eel River-specific literature (Brown 1990, Brown et al. 1994).

To develop WUA curves, target species and life stages most affected by freshwater habitat availability and their associated habitat needs were identified (Table G-1). Habitat Suitability Index (HIS) values were selected for each species-specific life stages and are described in Appendices E and F. A more complete discussion of the periodicity of Coho Salmon, Chinook Salmon, and steelhead in the South Fork Eel River is provided in the main Sproul Creek Instream Flow Study report.

Table G-1. Target species and life stages in the Sproul Creek watershed and their associated habitat variables.

Target Species and Life Stages	Modeled Habitat Variables
Adult Coho Salmon Spawning	Depth, Velocity, Substrate
Adult Steelhead Spawning	Depth, Velocity, Substrate
Adult Chinook Salmon Spawning	Depth, Velocity, Substrate
Fry Coho Salmon Rearing	Depth, Velocity, Distance to Cover
Fry Steelhead Rearing	Depth, Velocity, Distance to Cover
Juvenile Coho Salmon Rearing	Depth, Velocity, Distance to Cover
Juvenile Steelhead (small and large) Rearing	Depth, Velocity, Distance to Cover
Benthic Macroinvertebrate (BMI) Production	Depth, Velocity, Substrate

1.2 Study Area Description

Sproul Creek is a 24.0 mi^2 watershed, entering the South Fork Eel River 2.3 miles downstream from Benbow Dam, near Garberville, CA (**Error! Reference source not found.**). There are two study reaches based on the type of modeling conducted in each reach: 1-D modeling occurred on the South Fork Sproul Creek, and 2-D modeling occurred on the mainstem. The Upper South Fork (USF) study reach, located below the confluence of Cox Creek, is 1,893 ft long and composed primarily of riffle and pool habitat (**Error! Reference source not found.**). Specific mesohabitat unit types of the USF 1-D modeling reach and placement of hydraulic model cross sections are described in Appendix E. The Mainstem Sproul Creek study reach, beginning upstream of Warden Creek and ending at the confluence with Dry Trib, is 2,472 ft long and composed primarily of low gradient riffle and pool mesohabitat unit types. The UMS 2-D modeling reach is 308 ft long (12% of the entire study reach) and contains two complete riffle–pool sequences (i.e., two hydraulic units). Specific 2-D modeling site mesohabitat unit types are described in Appendix F.

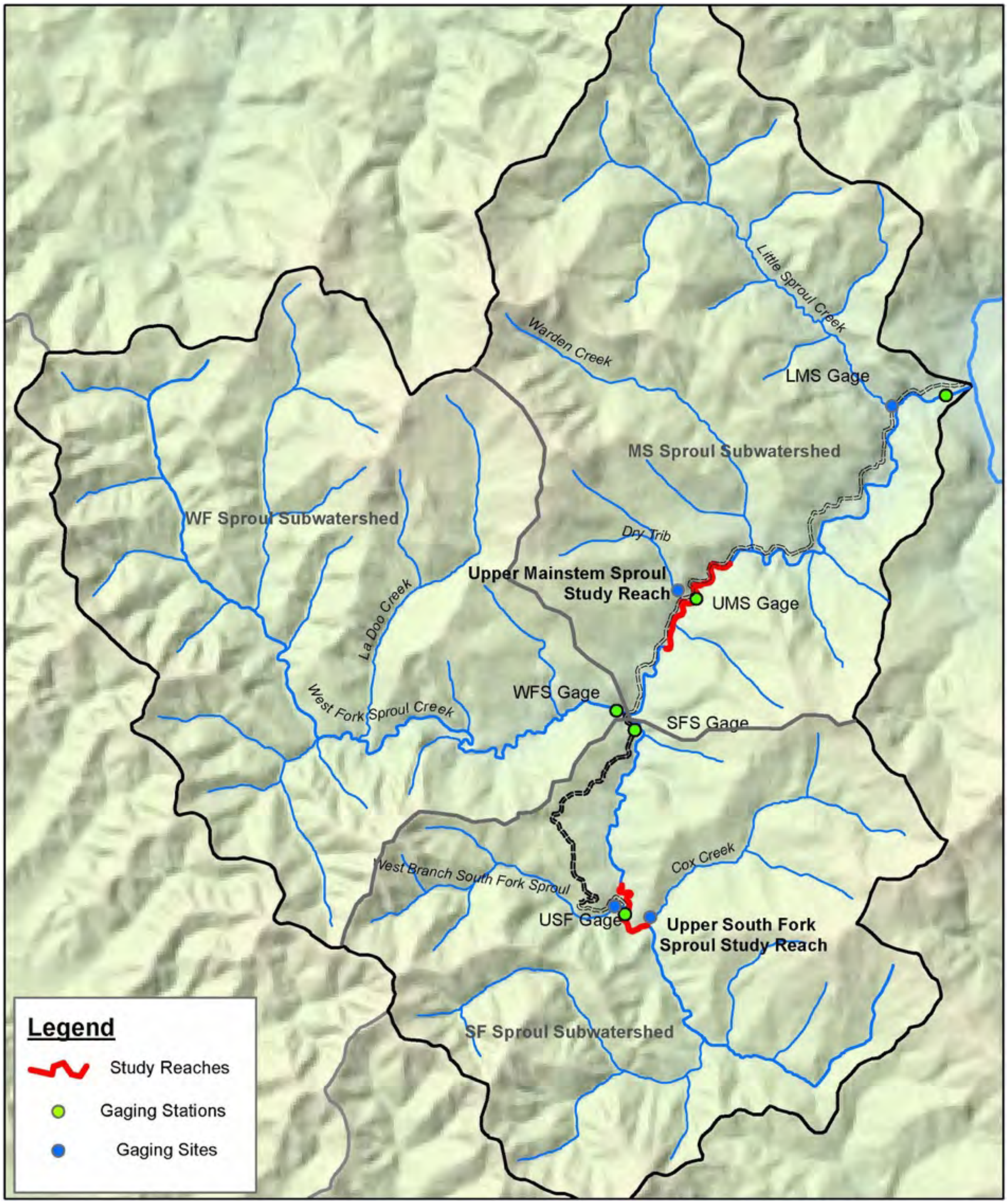


Figure G-2. Location of Sproul Creek, including the South Fork Sproul Creek 1-D modeling site and the mainstem Sproul Creek 2-D modeling site and associated mesohabitat types.

2 TIME-SERIES ANALYSIS METHODOLOGY

The time-series analysis is a method of characterizing the available habitat as it varies with time within a given river reach for each of the target species and life stages considered in this study. The method uses a daily time interval, separated by month, and was conducted for five equally weighted water year classes (20% exceedance classes): Extremely Wet, Wet, Normal, Dry, and Extremely Dry. For each target species and life stage, the time-series analysis computes a habitat index value (henceforth referred to as "weighted usable area" or "WUA") for all days in the 49-year period of flow record, then determines the unimpaired median daily WUA value for each month of the year and for each water year class. The time-series analysis procedure is outlined below and illustrated in Figure G-3:

1. Generate unimpaired annual hydrographs for Sproul Creek using the Bull Creek USGS streamflow record (described in Appendix A).
2. Convert annual hydrographs to annual WUA habitat graphs ("habigraphs") using WUA curves for each targeted species and life stage.
3. Identify the median WUA value for each month and by water year class (e.g., the median of every August day that occurred during a Dry water year). Do this for each targeted species and life stage.
4. Compute streamflow for the median habitat value computed in step 3 (in WUA) using the WUA curves for each targeted species and life stage.
5. Use resulting streamflows associated with monthly median WUA values as a basis for developing flow criteria for each of the study reaches.

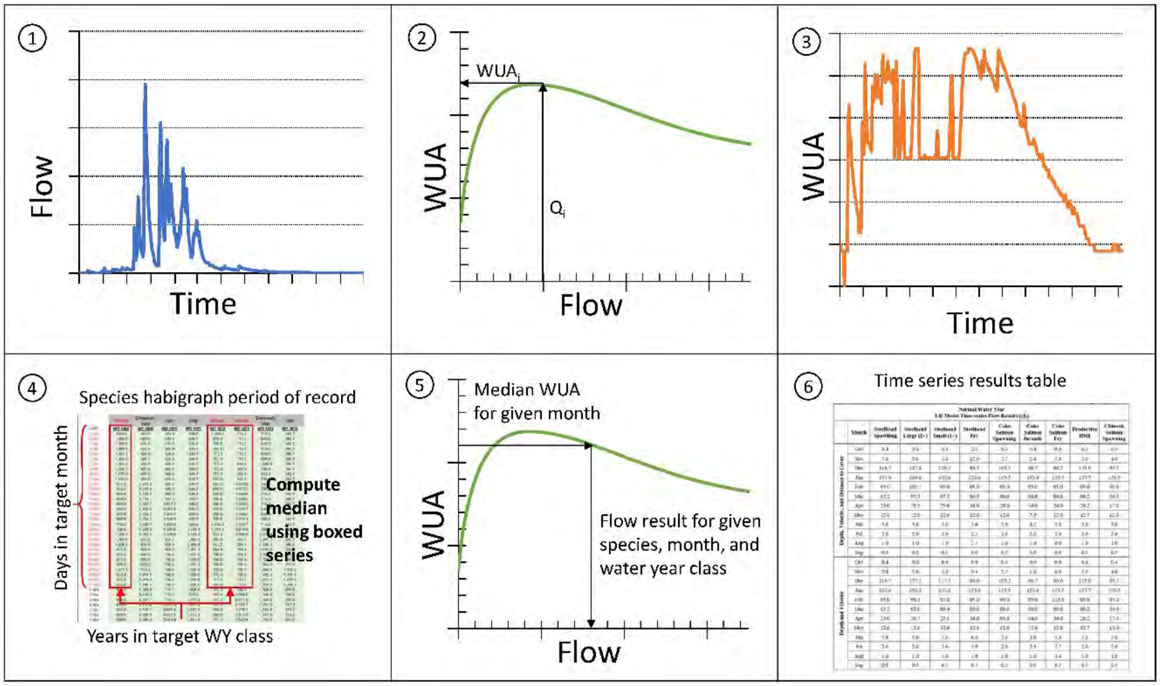


Figure G-3. Outline of the WUA time series analysis process: (1) Assemble unimpaired annual hydrographs for period of flow record, classified by water year type; (2) Use WUA curve to convert flow data to available habitat for targeted species and life stages; (3) Compute "habigraphs" i.e., daily estimate of WUA; (4) Compute the median daily WUA for each month, for all months of eachy water year class, for each targeted species and life stage; (5) Use WUA curves to estimate streamflow from median daily WUA values; (6) Repeat procedure for all months of each water year class; integrate results with other instream flow methods to develop flow criteria for each targeted species and life stages.

2.1 Annual Hydrographs

Unimpaired annual hydrographs for Sproul Creek were prepared using historic daily average streamflow records from the USGS Bull Creek near Weott gage (USGS 11476600) and two years of streamflow data collected in Sproul Creek. Gaging stations were installed at Lower Mainstem Sproul Creek near the confluence with the SF Eel River in May 2015, and at the Upper South Fork Sproul Creek 1-D modeling site and the Upper Mainstem Sproul Creek 2-D modeling site in April 2016. The 49-year period of record from Bull Creek extends from WY 1968 to WY 2016. To convert Bull Creek data to Sproul Creek, we used the formula recommended by the SWRCB (Mann et al. 2004), which incorporates a drainage basin area-ratio for statistical transfer, as well as a precipitation ratio to account for differences in precipitation between watersheds:

$$Sproul\ Creek\ Streamflow = Bull\ Creek\ Streamflow \times (24.0/28.1) \times (69.4/99.7) = 0.59$$

We refined the conversion of Bull Creek data to Sproul Creek for flows less than 2 cfs using a regression of measured Sproul Creek to Bull Creek daily average streamflows. Thus, for flows above 2 cfs, the drainage area and rainfall ratio of 0.59 was used, and for flows below 2 cfs, a linear regression equation was applied. Once Bull Creek gaging data were converted to Sproul Creek, the data was then converted to the 1-D and 2-D modeling sites based only on drainage area. The Upper South Fork Sproul Creek has a 5.0 mi^2 drainage area, the Upper Mainstem Sproul Creek has a 17.0 mi^2 drainage area. For a detailed description of the preparation of unimpaired annual hydrographs and water year classification for Sproul Creek, please refer to Appendix A.

Annual hydrographs were sorted by water year class (i.e., Extremely Wet, Wet, Normal, Dry, and Extremely Dry). There are 10 years of data for each of the water year classes except the Wet water year class, which only has nine. Characteristics of the different water year classes, such as differences in magnitude of flow event, and the variability in flow between water years within a given class, can be visualized by plotting all hydrographs for the entire period of record, color-coded by water year class (Figure G-4, Figure G-5).

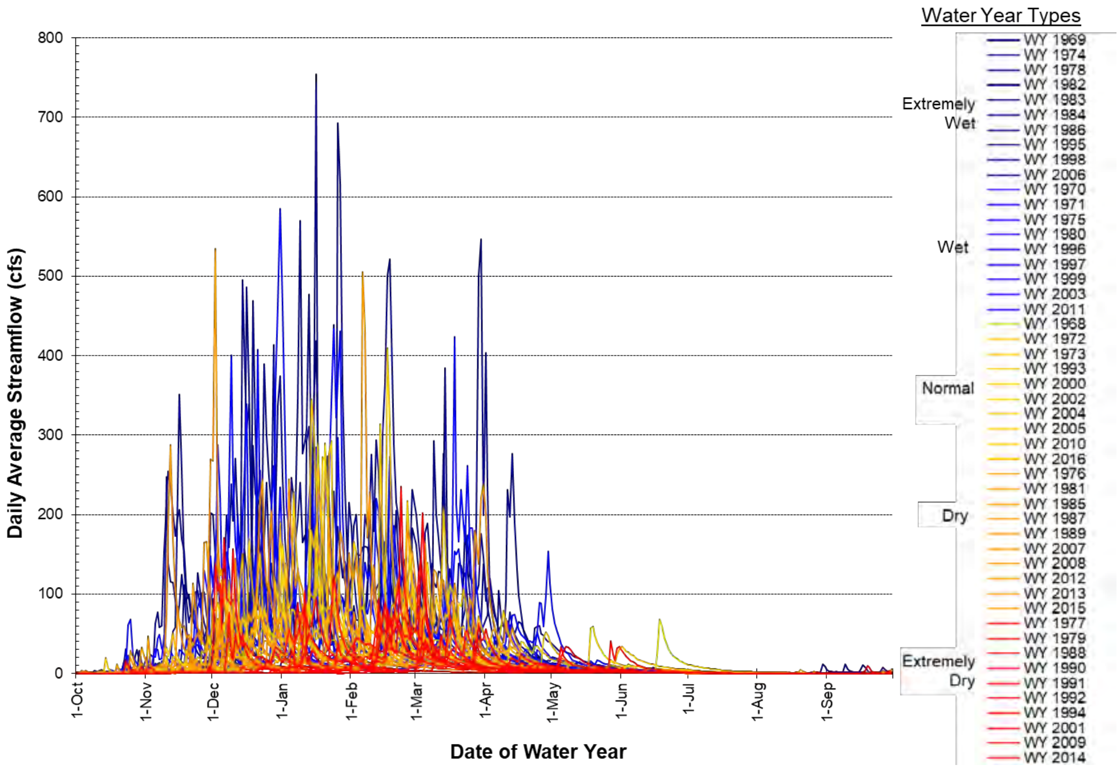


Figure G-4. Hydrographs for South Fork Sproul Creek (1-D hydraulic modeling site) dating from WY 1968 to WY 2016, grouped by water year class.

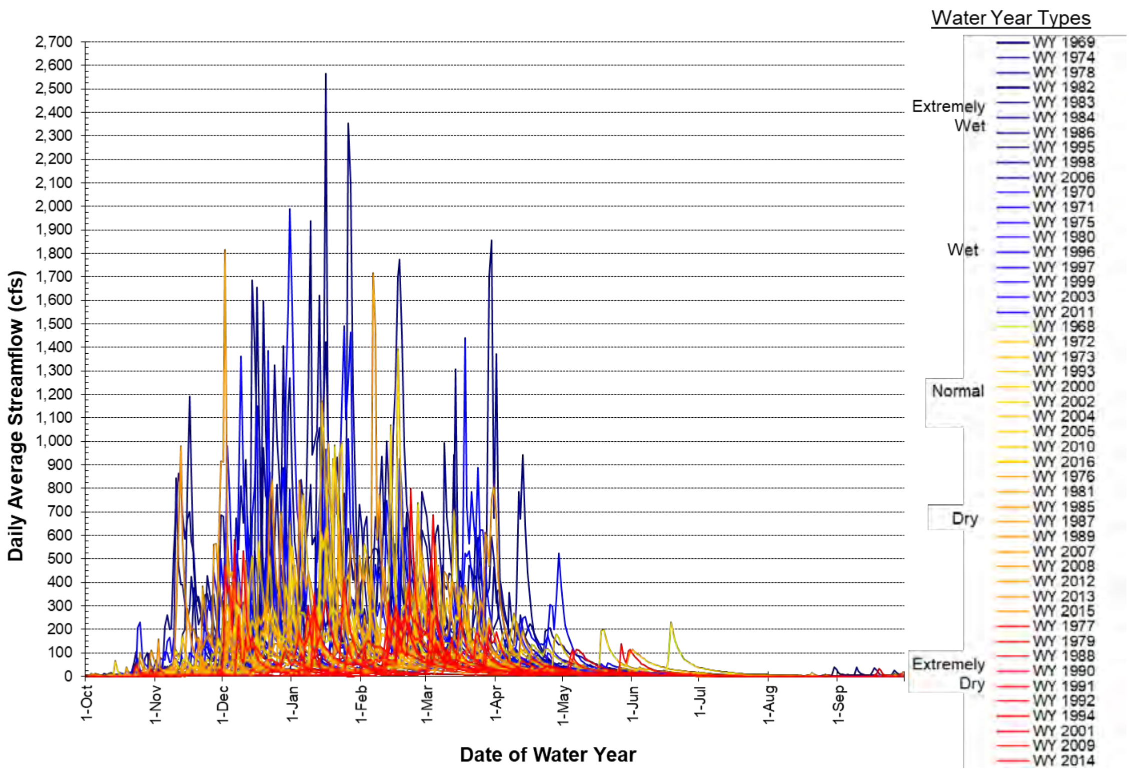


Figure G-5. Hydrographs for mainstem Sproul Creek (2-D hydraulic modeling site) dating from SY 1968 to WY 2016, grouped by water year class.

2.2 Annual Hydrographs to Habigraphs

The 1-D and 2-D modeling site annual hydrographs were converted to annual habigraphs over the entire period of record using the WUA curves for each targeted species and life stage. A habigraph is a representation of the available WUA in a reach as it fluctuates in response to changes in streamflow throughout the year. For each mean daily streamflow on the hydrograph, the corresponding WUA values from the WUA curves were used to generate analogous points on the habigraph. Mesohabitat mapping conducted at the 1-D modeling site allowed WUA curves to be generated for the three most significant habitat categories: riffles, pools, and the whole reach (riffles and pools combined, Figure G-6 through Figure G-8). Results of the 1-D modeling site time-series analysis are subdivided by these mesohabitat types. WUA curves for all 1-D model runs use the water depth, velocity, and cover availability HSI (see Appendix E). The WUA curves associated with the 2-D modeling site are separated into two categories: with and without the inclusion of the "distance to cover" HSI when calculating WUA (Figure G-9, Figure G-10). Results of the 2-D modeling site time-series analysis are subdivided into these two categories. For both the 1-D and 2-D model runs, WUA curves for productive BMI and adult spawning for all species use the water depth, velocity, and substrate HSI. The range of modeled flows for the 1-D modeling site WUA curves extends from 0 cfs to 70 cfs, while the range for the 2-D modeling site curves extends from 0.5 cfs to 190 cfs. These ranges of streamflow were selected to bracket the full range of median WUA values for all months and water year classes. Because the 2-D modeling site is fed by a larger drainage area than the 1-D site, higher flows were modeled at the 2-D site to fully bracket median WUA.

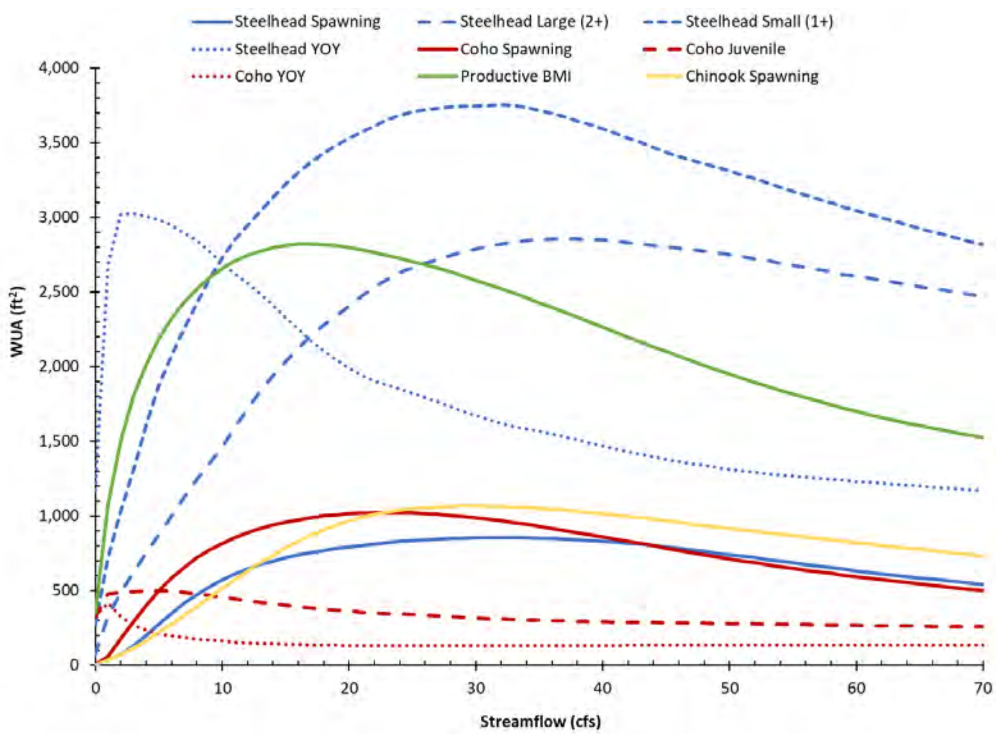


Figure G-6. Upper South fork Sproul Creek 1-D modeling site WUA curves for targeted species and life stages in riffle mesohabitat units using water depth, velocity, and distance to cover HSI. Depth, velocity, and substrate HSI were used for productive BMI and all spawning WUA curves.

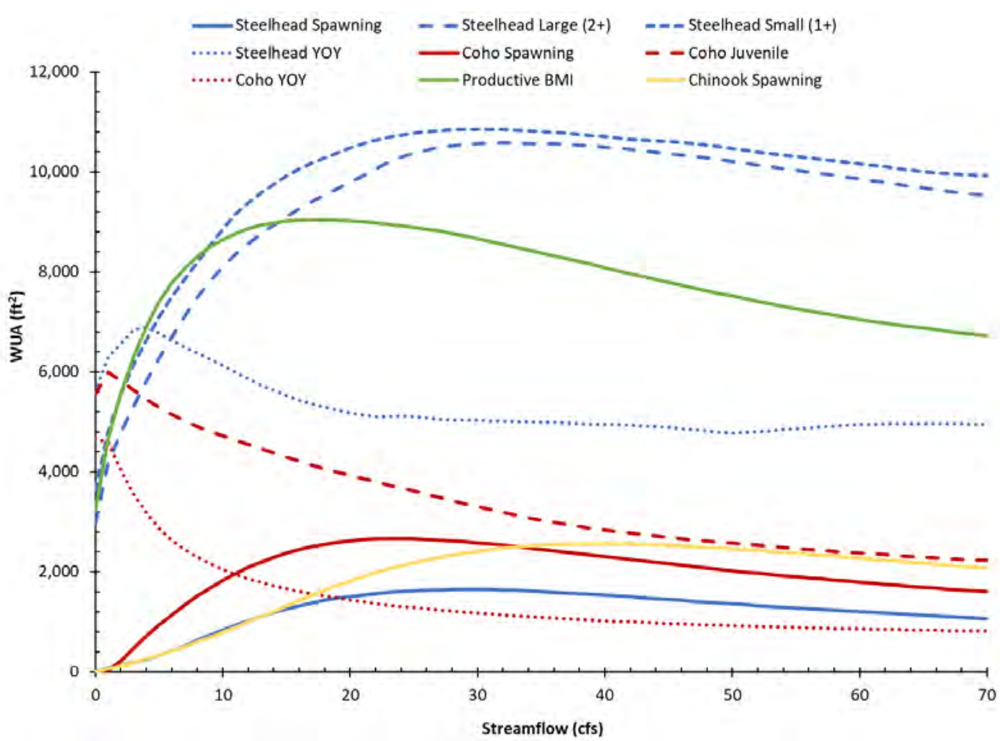


Figure G-7. Upper South fork Sproul Creek 1-D modeling site WUA curves for targeted species and life stages in pool mesohabitat units using depth, velocity, and distance to cover HSI. Depth, velocity, and substrate HSI were used for productive BMI and all spawning WUA curves.

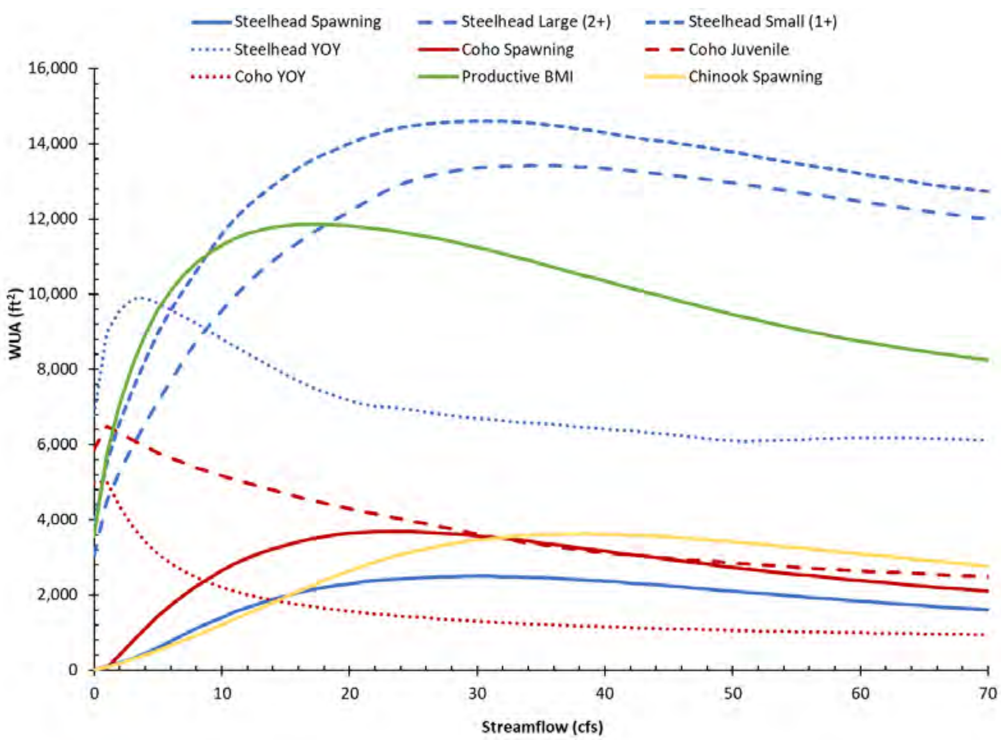


Figure G-8. South fork Sproul Creek 1-D modeling site WUA curves for targeted species and life stages in the whole reach (riffle and pool mesohabitat units) using water depth, velocity, and distance to cover HSI. Depth, velocity, and substrate HSI were used for productive BMI and all spawning WUA curves.

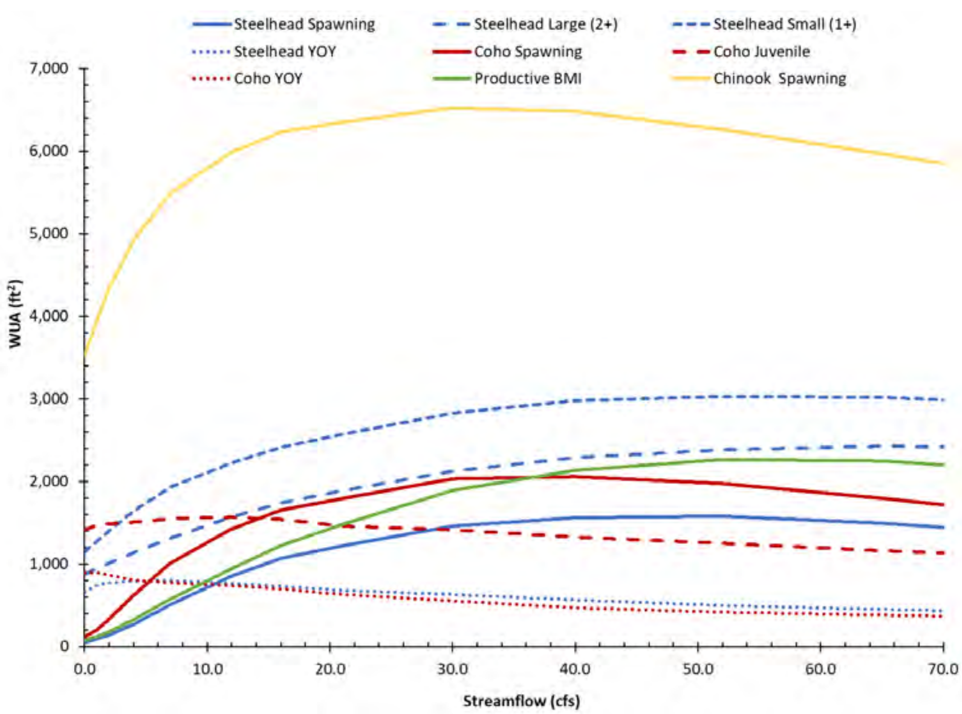


Figure G-9. Mainstem Sproul Creek 2-D modeling site WUA curves for targeted species and life stages using depth, velocity, and distance to cover HSI. Depth, velocity, and substrate HSI were used for productive BMI and all spawning WUA curves.

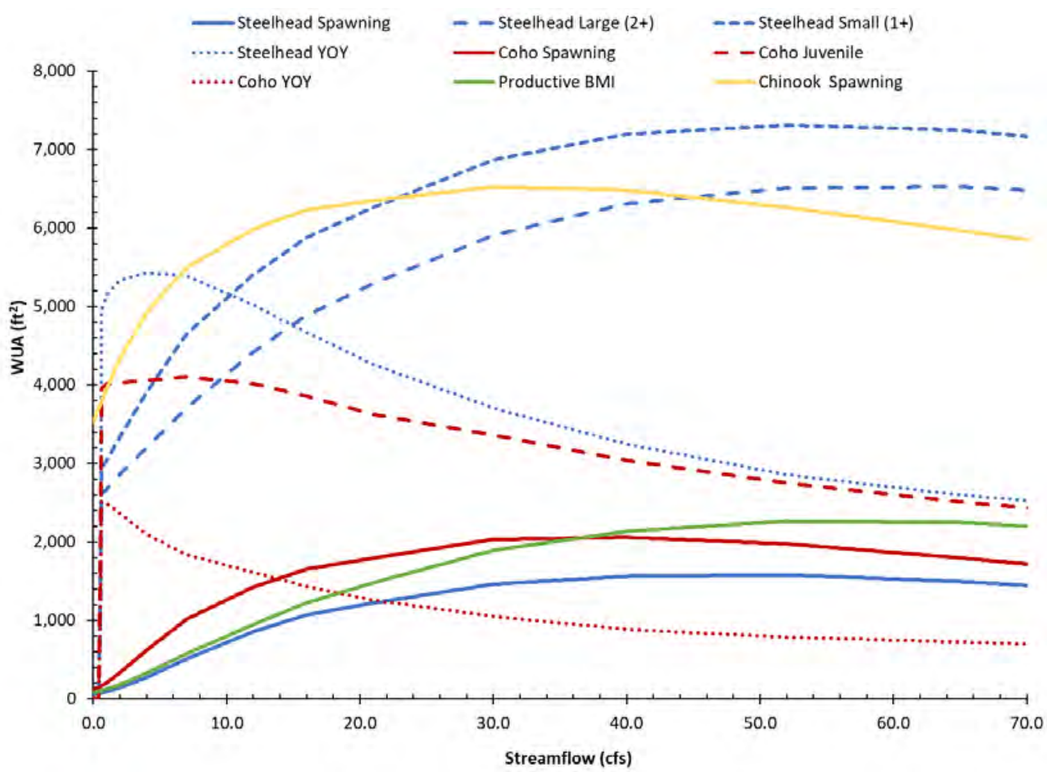


Figure G-10. Mainstem Sproul Creek 2-D modeling site WUA curves for targeted species and life stages using depth and velocity HSI. Depth, velocity, and substrate HSI were used for productive BMI and all spawning WUA curves.

Converting hydrographs to habigraphs demonstrates the seasonal variation and stochasticity of the unimpaired annual hydrographs. Because the WUA curves are dependent on multiple variables and do not follow simple functional relationships, the resulting habigraphs do not necessarily assume the same pattern as the hydrograph (Figure G-11). This means that increasing streamflows does not necessarily result in increasing habitat. For example, in Figure G-11, high flows during the wet season (December through June) elicit a rise in WUA for large (2+) juvenile steelhead compared to baseflow months, while juvenile Coho Salmon experience a decline in WUA from baseflow levels during this same period. Additionally, a change in streamflow does not necessarily result in a proportional magnitude of change in WUA (e.g., streamflows corresponding to flatter segments of a WUA curve).

The different preferences in habitat conditions between target species and life stages causes certain species/life stages to experience greater habitat availability than others depending on water year class and time of year (Figure G-13 through Figure G-20 for 1-D modeling site and Figure G-21 through Figure G-28 for 2-D modeling site). In general, certain species (e.g., large juvenile steelhead, Figure G-13) tend to favor higher flows and consequently will have more available habitat during the peak storm season of Wet and Extremely Wet water years than during Dry and Extremely Dry years. Conversely, other species (e.g., juvenile Coho Salmon, Figure G-17) benefit from lower flows and have the least available habitat during the peak storm season of Wet and Extremely Wet years. For both examples, differences in WUA between water year class become more marginal when Sproul Creek is at or near baseflow. For this reason, it is important to consider the timing of spawning, incubation/emergence, and migration/outmigration activity relative to local hydrology when making streamflow management decisions.

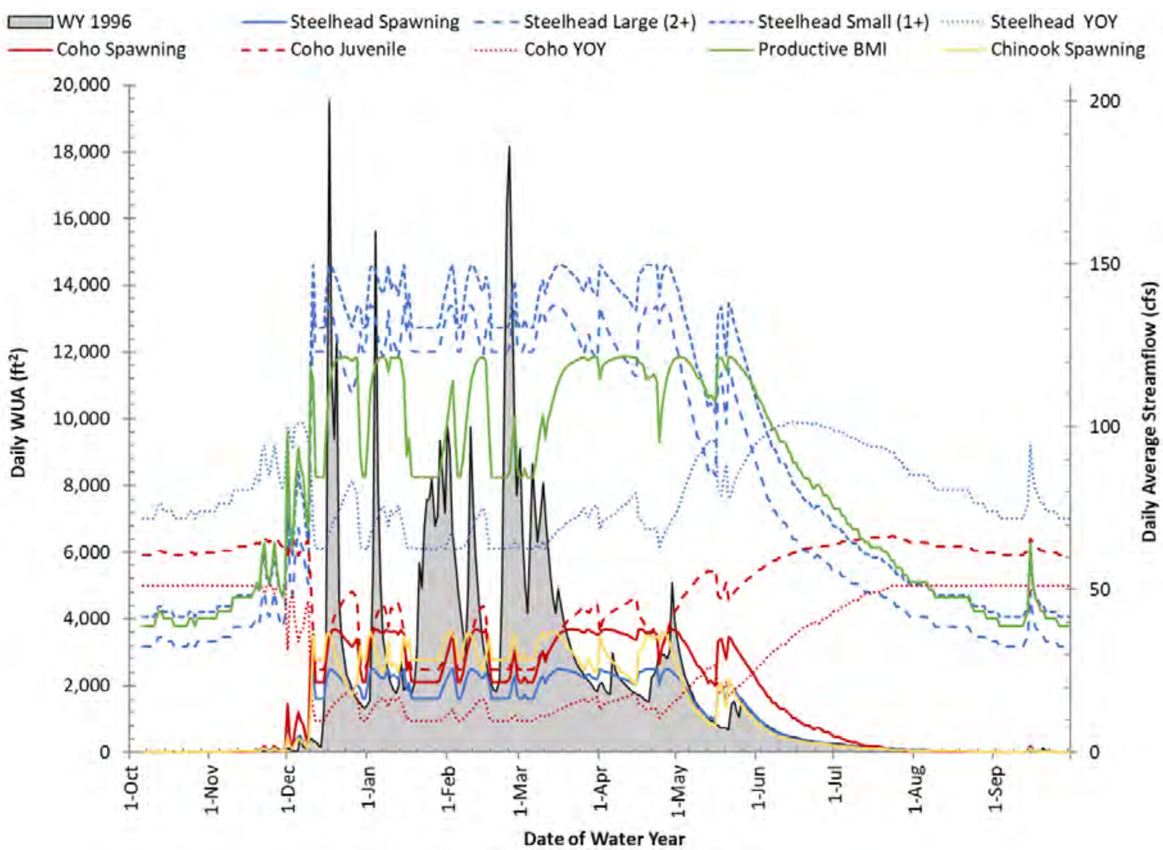


Figure G-11. Unimpaired hydrograph and daily whole-reach habigraphs for a representative Wet water year (1996), illustrating how WUA responds to changes in flow and how the magnitude and pattern of this response differs amongst targeted species and life stages.

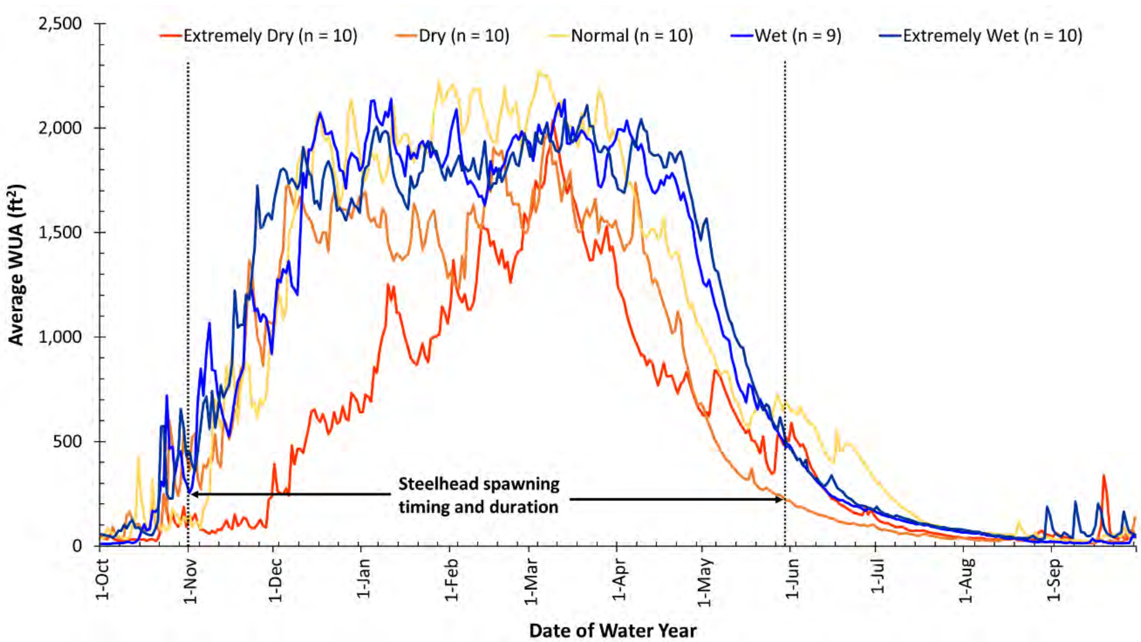


Figure G-12. Adult steelhead spawning habigraphs for the 1-D modeling site (whole reach) showing WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

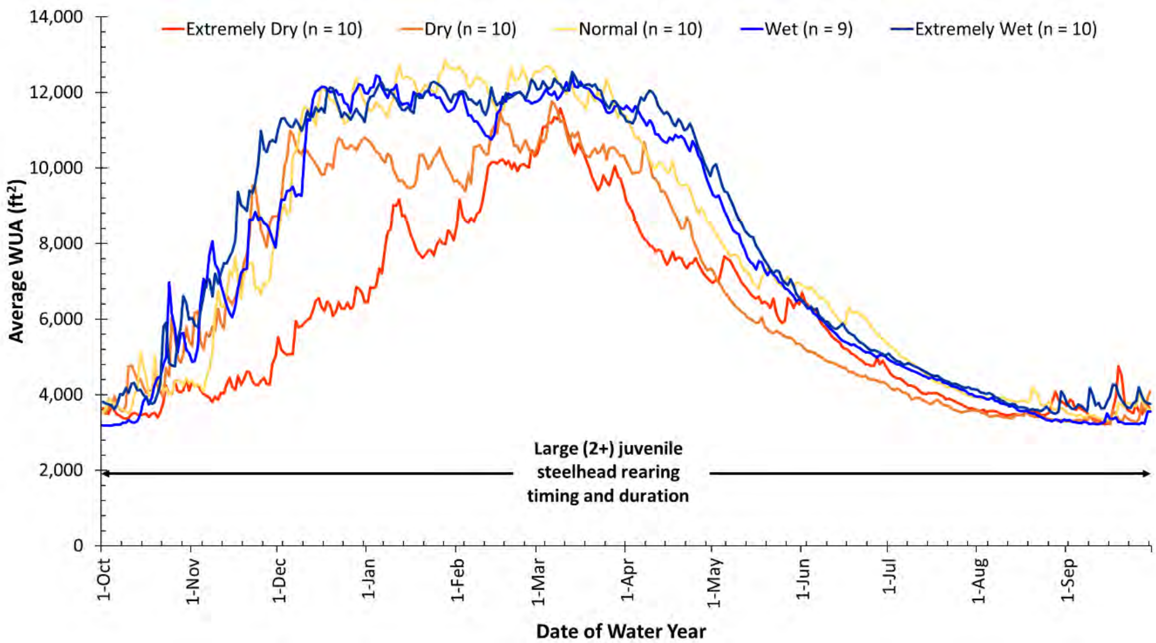


Figure G-13. Large (2+) juvenile steelhead rearing habigraphs for the 1-D modeling site (whole reach) showing average WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

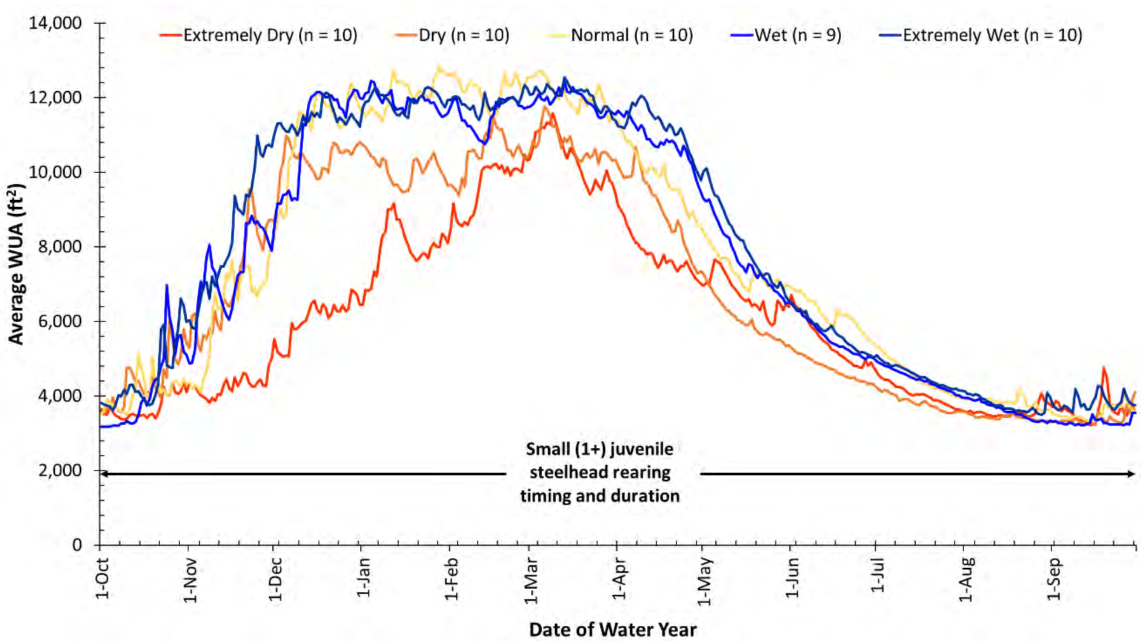


Figure G-14. Small (1+) juvenile steelhead rearing habigraphs for the 1-D modeling site (whole reach) showing average WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

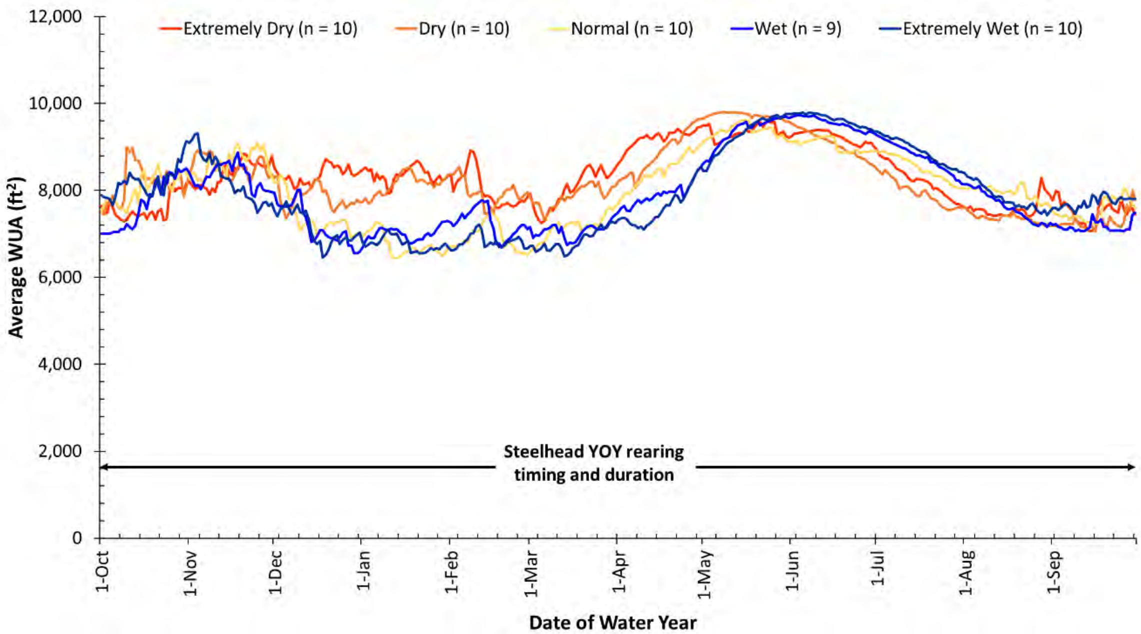


Figure G-15. Steelhead fry rearing habigraphs for the 1-D modeling site (whole reach) showing average WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

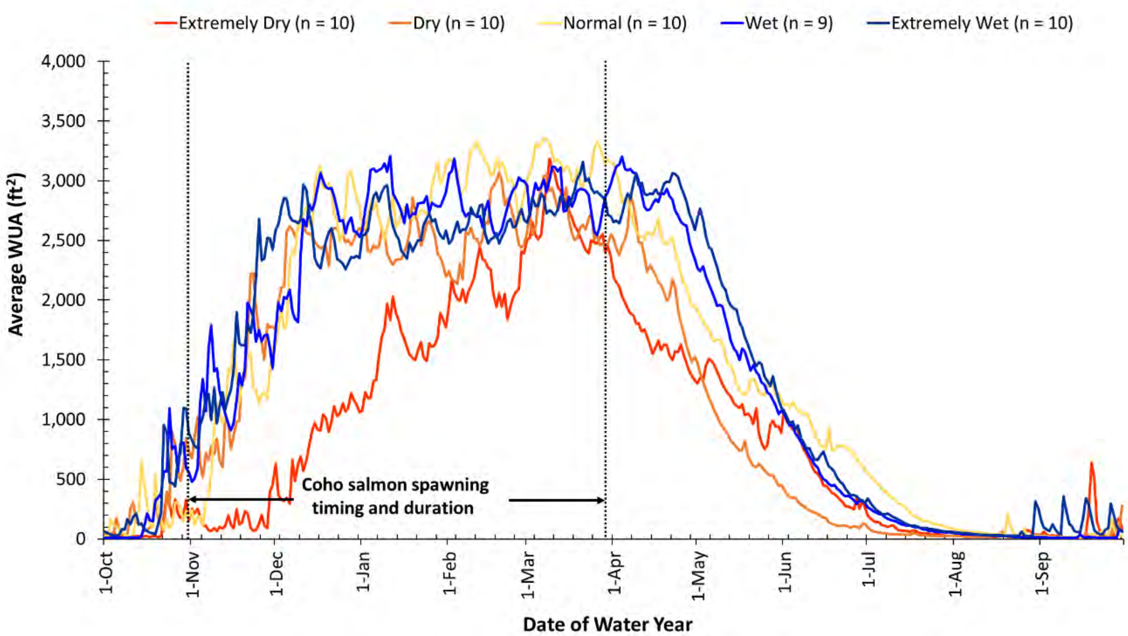


Figure G-16. Adult Coho Salmon spawning habigraphs for the 1-D modeling site (whole reach) showing average WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

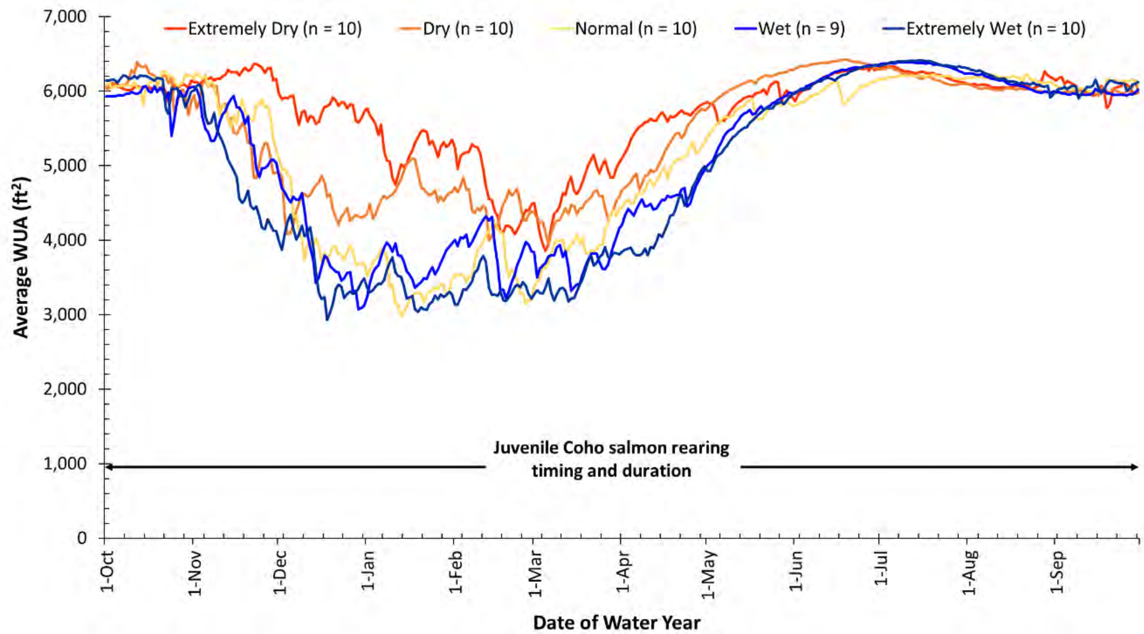


Figure G-17. Juvenile Coho Salmon rearing habigraphs for the 1-D modeling site (whole reach) showing average WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

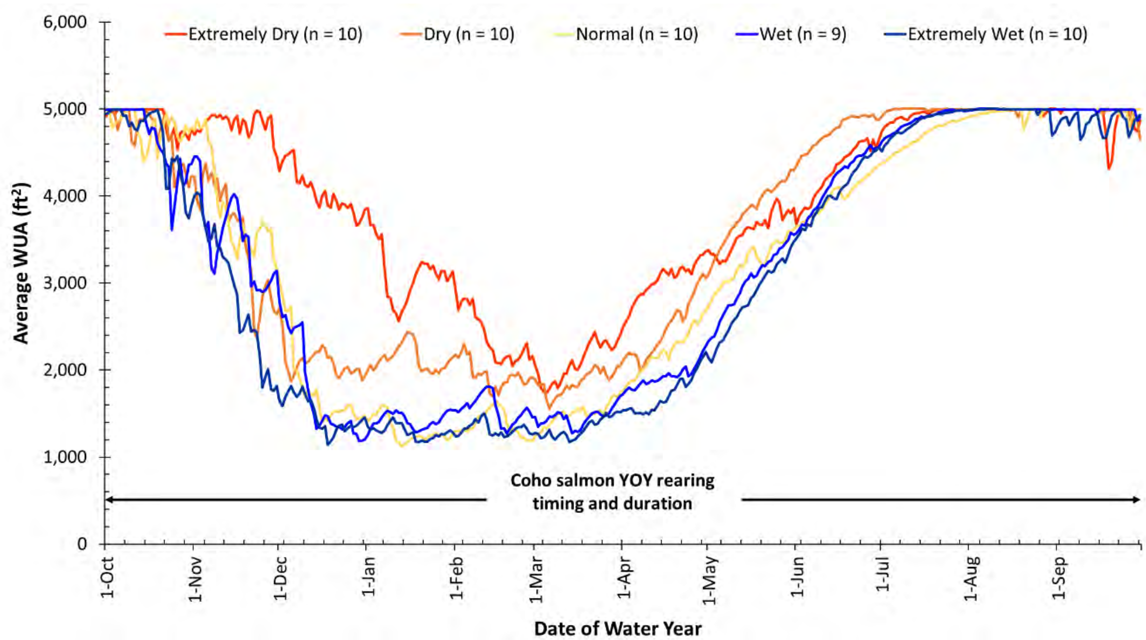


Figure G-18. Coho Salmon fry rearing habigraphs for the 1-D modeling site (whole reach) showing average WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

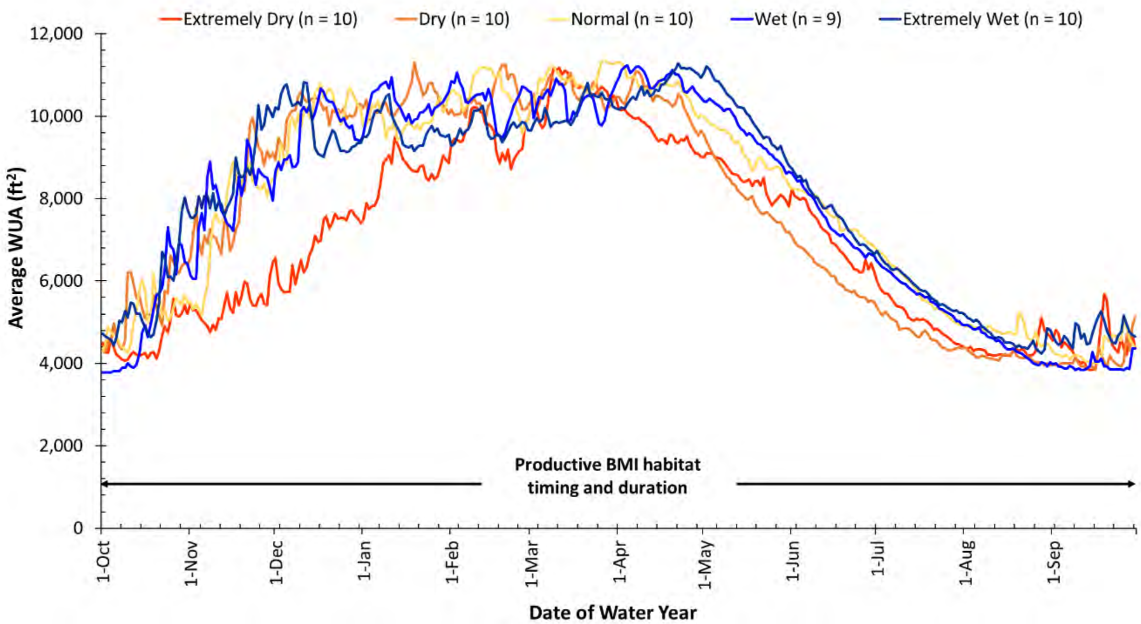


Figure G-19. Productive benthic macroinvertebrate (BMI) habigraphs for the 1-D modeling site (whole reach) showing average WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

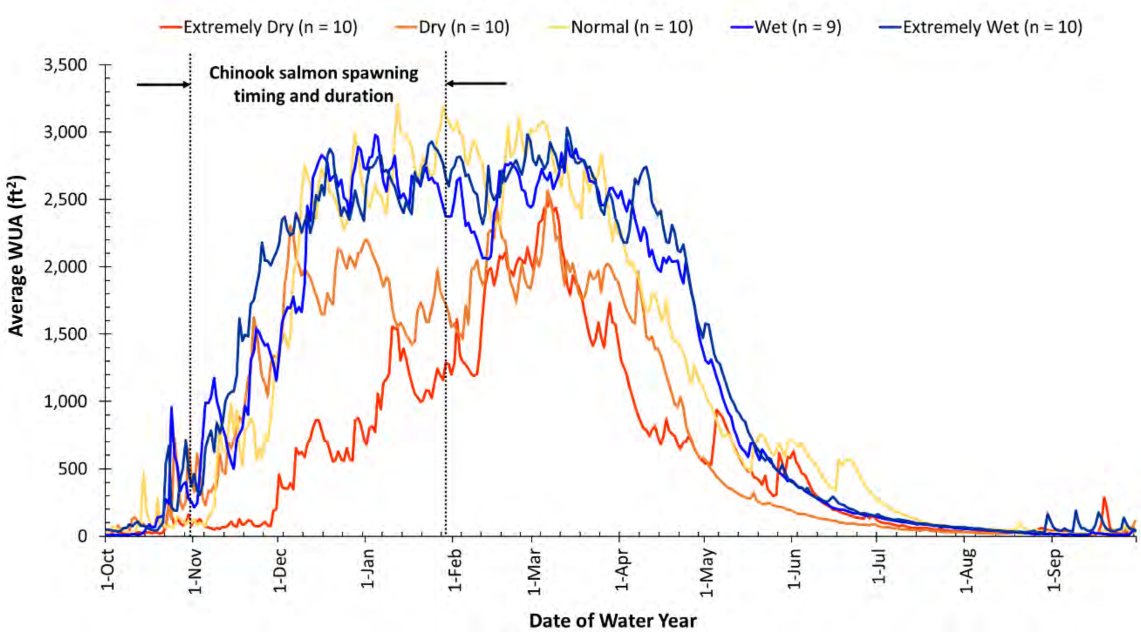


Figure G-20. Adult Chinook Salmon spawning habigraphs for the 1-D modeling site (whole reach) showing average WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

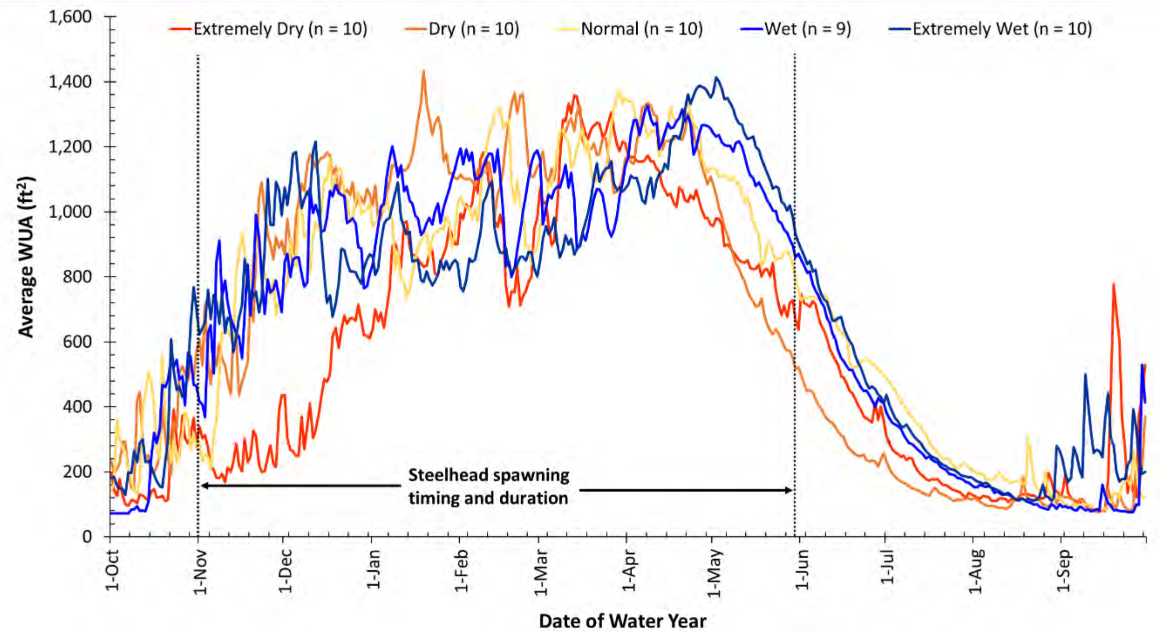


Figure G-21. Adult steelhead spawning habigraphs for the 2-D modeling site (water depth, velocity, and distance to cover) showing WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

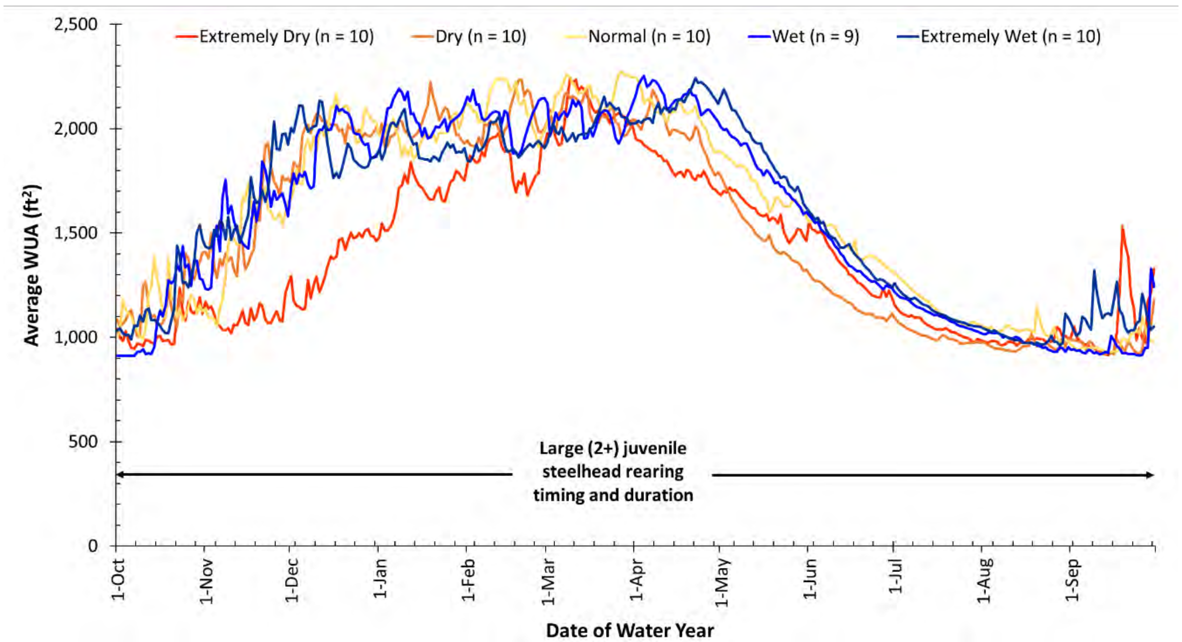


Figure G-22. Large (2+) juvenile steelhead rearing habigraphs for the 2-D modeling site (water depth, velocity, and distance to cover) showing WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

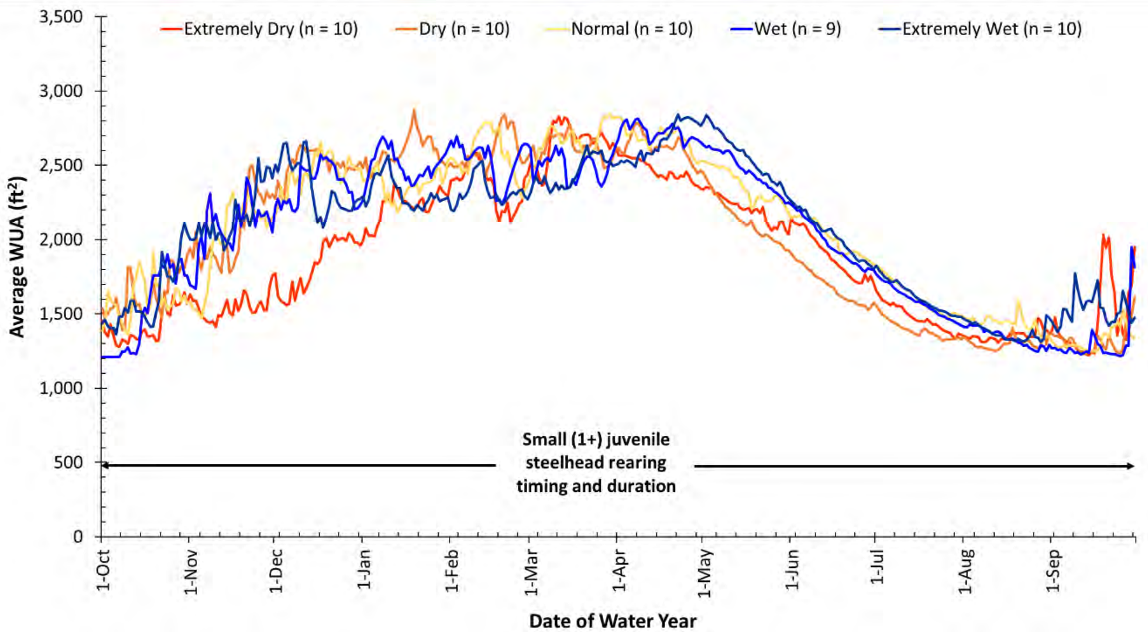


Figure G-23. Small (1+) juvenile steelhead rearing habigraphs for the 2-D modeling site (water depth, velocity, and distance to cover) showing WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

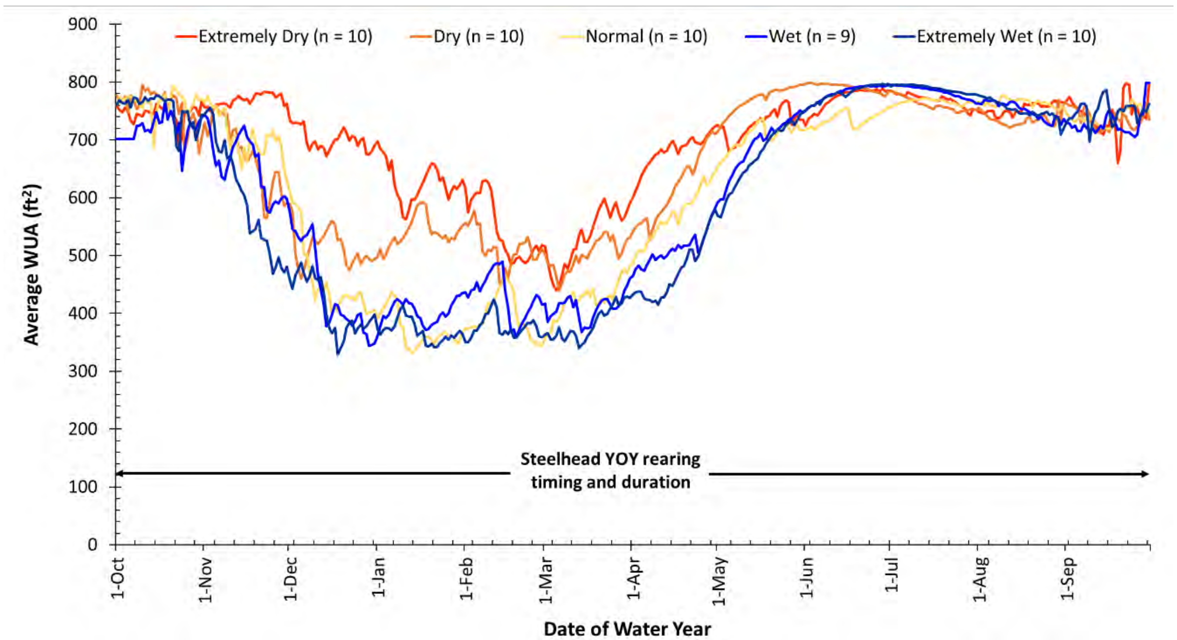


Figure G-24. Steelhead fry rearing habigraphs for the 2-D modeling site (water depth, velocity, and distance to cover) showing WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

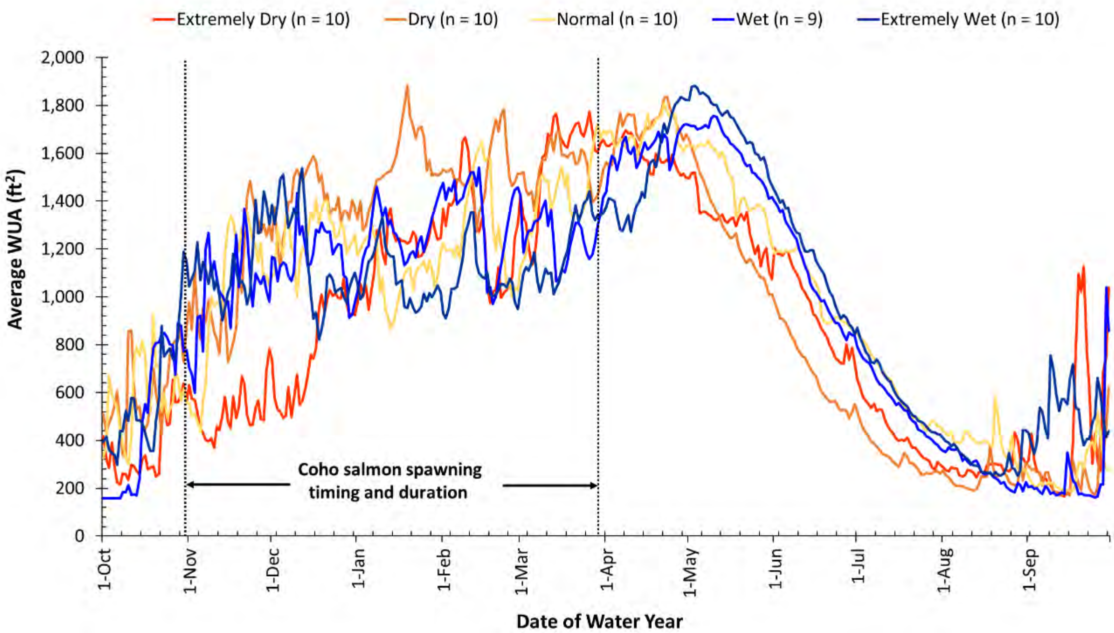


Figure G-25. Adult Coho Salmon spawning habigraphs for the 2-D modeling site (water depth, velocity, and distance to cover) showing WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

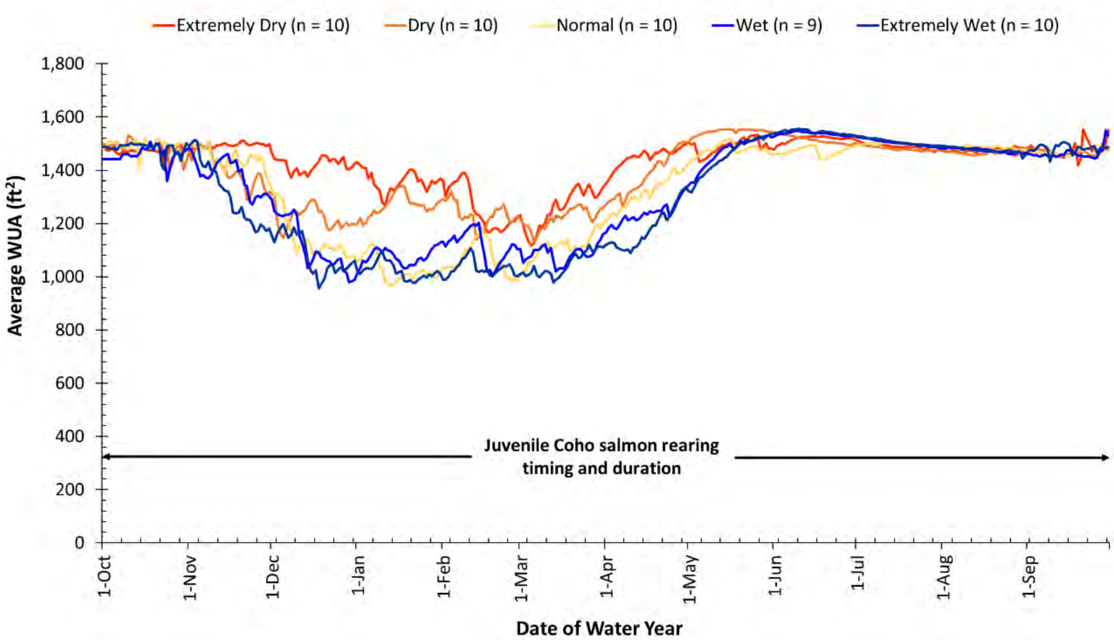


Figure G-26. Juvenile Coho Salmon rearing habigraphs for the 2-D modeling site (water depth, velocity, and distance to cover) showing WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

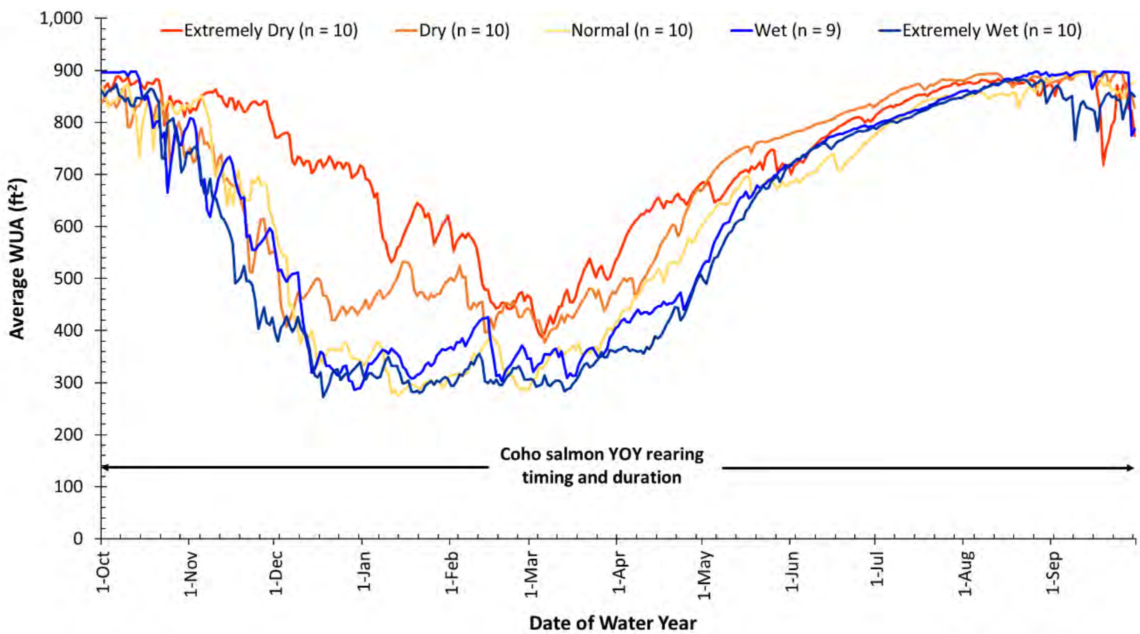


Figure G-27. Coho Salmon fry rearing habigraphs for the 2-D modeling site (water depth, velocity, and distance to cover) showing WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

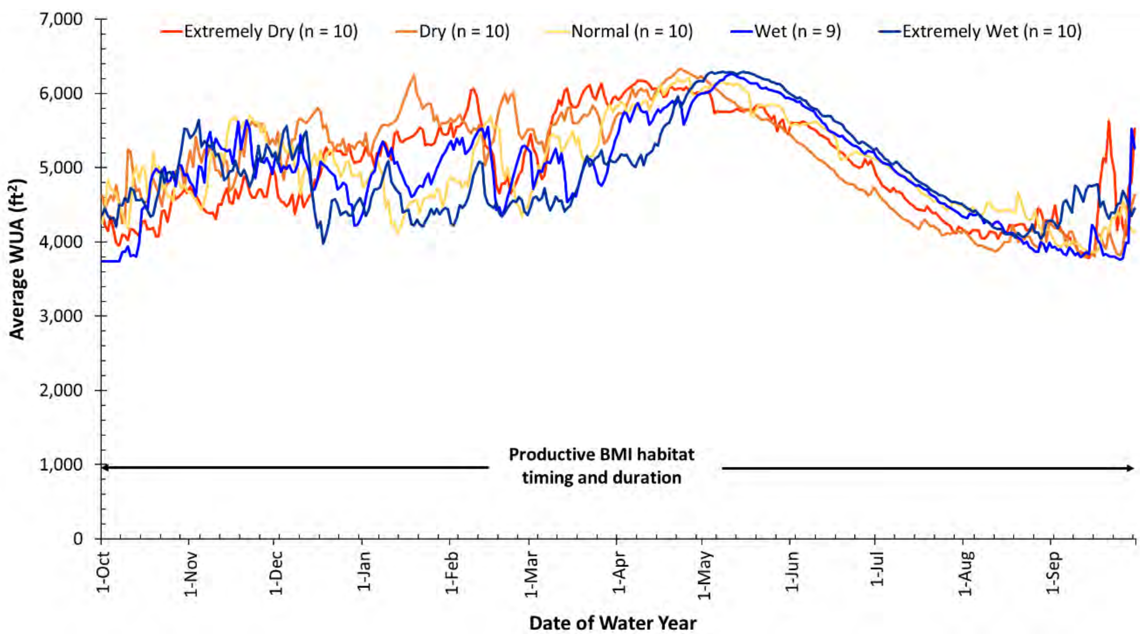
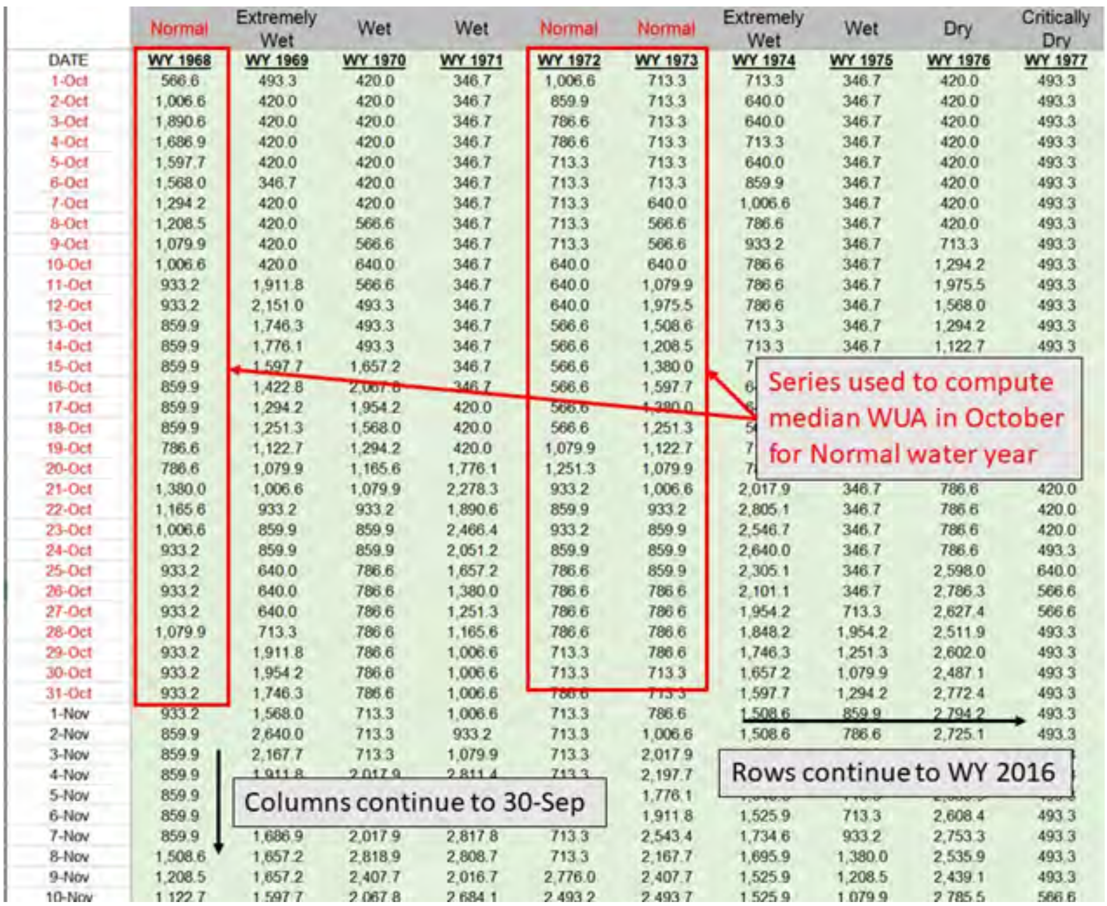


Figure G-28. Productive benthic macroinvertebrate (BMI) habigraphs for the 2-D modeling site (water depth, velocity, and distance to cover) showing WUA for each day of the water year, averaged over n *years in the period of record that fall into each water year class.*

2.3 Median WUA to Streamflow

Using the habigraph data, the median WUA values for each month of each water year class were identified for all targeted species and life stages. Only WUA data that fall within a given month and that occur in a particular water year class are used in determining the median WUA values for each targeted species and life stage (Figure G-29). The daily average streamflow corresponding to each median WUA value was computed using the WUA curves. Due to the shape of the WUA curves, there are values of WUA that can occur at two possible streamflows (Figure G-30). In these instances, the flow value closest to the median flow for each given month and water year class was used. Thus, the higher of the two flow values was accepted for months during which Sproul Creek had higher streamflow. Conversely, the lower value was used for months during which the higher flow value is not expected to normally occur. For example, it is possible for 2,000 ft^2 of productive BMI WUA (riffles-only curve) to occur in both October and March. However, based on the WUA curve in Figure G-30, it is most likely that this value corresponds to 48 cfs in March during the wet season when flows are high, and to 4 cfs in October when Sproul Creek is still at summer baseflow and a streamflow of 48 cfs is statistically very unlikely to occur. This rationale was applied to eliminate unrealistically high or low flow results from the analysis.



	Normal	Extremely Wet	Wet	Wet	Normal	Normal	Extremely Wet	Wet	Dry	Critically Dry
DATE	WY 1968	WY 1969	WY 1970	WY 1971	WY 1972	WY 1973	WY 1974	WY 1975	WY 1976	WY 1977
1-Oct	566.6	493.3	420.0	346.7	1,006.6	713.3	713.3	346.7	420.0	493.3
2-Oct	1,006.6	420.0	420.0	346.7	859.9	713.3	640.0	346.7	420.0	493.3
3-Oct	1,890.6	420.0	420.0	346.7	786.6	713.3	640.0	346.7	420.0	493.3
4-Oct	1,686.9	420.0	420.0	346.7	786.6	713.3	713.3	346.7	420.0	493.3
5-Oct	1,597.7	420.0	420.0	346.7	713.3	713.3	640.0	346.7	420.0	493.3
6-Oct	1,568.0	346.7	420.0	346.7	713.3	713.3	859.9	346.7	420.0	493.3
7-Oct	1,294.2	420.0	420.0	346.7	713.3	640.0	1,006.6	346.7	420.0	493.3
8-Oct	1,208.5	420.0	566.6	346.7	713.3	566.6	786.6	346.7	420.0	493.3
9-Oct	1,079.9	420.0	566.6	346.7	713.3	566.6	933.2	346.7	713.3	493.3
10-Oct	1,006.6	420.0	640.0	346.7	640.0	640.0	786.6	346.7	1,294.2	493.3
11-Oct	933.2	1,911.8	566.6	346.7	640.0	1,079.9	786.6	346.7	1,975.5	493.3
12-Oct	933.2	2,151.0	493.3	346.7	640.0	1,975.5	786.6	346.7	1,568.0	493.3
13-Oct	859.9	1,746.3	493.3	346.7	566.6	1,508.6	713.3	346.7	1,294.2	493.3
14-Oct	859.9	1,776.1	493.3	346.7	566.6	1,208.5	713.3	346.7	1,122.7	493.3
15-Oct	859.9	1,597.7	1,657.2	346.7	566.6	1,380.0	[illegible]	[illegible]	[illegible]	[illegible]
16-Oct	859.9	1,422.8	[illegible]	346.7	566.6	1,597.7	[illegible]	[illegible]	[illegible]	[illegible]
17-Oct	859.9	1,294.2	1,954.2	420.0	566.6	1,380.0	[illegible]	[illegible]	[illegible]	[illegible]
18-Oct	859.9	1,251.3	1,568.0	420.0	566.6	1,251.3	[illegible]	[illegible]	[illegible]	[illegible]
19-Oct	786.6	1,122.7	1,294.2	420.0	1,079.9	1,122.7	[illegible]	[illegible]	[illegible]	[illegible]
20-Oct	786.6	1,079.9	1,165.6	1,776.1	1,251.3	1,079.9	[illegible]	[illegible]	[illegible]	[illegible]
21-Oct	1,380.0	1,006.6	1,079.9	2,278.3	933.2	1,006.6	2,017.9	346.7	786.6	420.0
22-Oct	1,165.6	933.2	933.2	1,890.6	859.9	933.2	2,805.1	346.7	786.6	420.0
23-Oct	1,006.6	859.9	859.9	2,466.4	933.2	859.9	2,546.7	346.7	786.6	420.0
24-Oct	933.2	859.9	859.9	2,051.2	859.9	859.9	2,640.0	346.7	786.6	493.3
25-Oct	933.2	640.0	786.6	1,657.2	786.6	859.9	2,305.1	346.7	2,598.0	640.0
26-Oct	933.2	640.0	786.6	1,380.0	786.6	786.6	2,101.1	346.7	2,786.3	566.6
27-Oct	933.2	640.0	786.6	1,251.3	786.6	786.6	1,954.2	713.3	2,627.4	566.6
28-Oct	1,079.9	713.3	786.6	1,165.6	786.6	786.6	1,848.2	1,954.2	2,511.9	493.3
29-Oct	933.2	1,911.8	786.6	1,006.6	713.3	786.6	1,746.3	1,251.3	2,602.0	493.3
30-Oct	933.2	1,954.2	786.6	1,006.6	713.3	713.3	1,657.2	1,079.9	2,487.1	493.3
31-Oct	933.2	1,746.3	786.6	1,006.6	786.6	713.3	1,597.7	1,294.2	2,772.4	493.3
1-Nov	933.2	1,568.0	713.3	1,006.6	713.3	786.6	1,508.6	859.9	2,794.2	493.3
2-Nov	859.9	2,640.0	713.3	933.2	713.3	1,006.6	1,508.6	786.6	2,725.1	493.3
3-Nov	859.9	2,167.7	713.3	1,079.9	713.3	2,017.9	[illegible]	[illegible]	[illegible]	[illegible]
4-Nov	859.9	1,911.8	2,017.9	2,811.4	713.3	2,197.7	[illegible]	[illegible]	[illegible]	[illegible]
5-Nov	859.9	[illegible]	[illegible]	[illegible]	[illegible]	1,776.1	[illegible]	[illegible]	[illegible]	[illegible]
6-Nov	859.9	[illegible]	[illegible]	[illegible]	[illegible]	1,911.8	1,525.9	713.3	2,608.4	493.3
7-Nov	859.9	1,686.9	2,017.9	2,817.8	713.3	2,543.4	1,734.6	933.2	2,753.3	493.3
8-Nov	1,508.6	1,657.2	2,818.9	2,808.7	713.3	2,167.7	1,695.9	1,380.0	2,535.9	493.3
9-Nov	1,208.5	1,657.2	2,407.7	2,016.7	2,776.0	2,407.7	1,525.9	1,208.5	2,439.1	493.3
10-Nov	1,122.7	1,597.7	2,067.8	2,684.1	2,493.2	2,493.7	1,525.9	1,079.9	2,785.5	566.6

Figure G-29. Sample of productive BMI habigraph data illustrating how the median WUA for October in Normal water years is calculated. Only values boxed in red are used to select the median. Cells are populated with the WUA value computed from the corresponding flow on the hydrograph for the given day in the given water year. This process was repeated for each month in each water year class for targeted species and life stages.

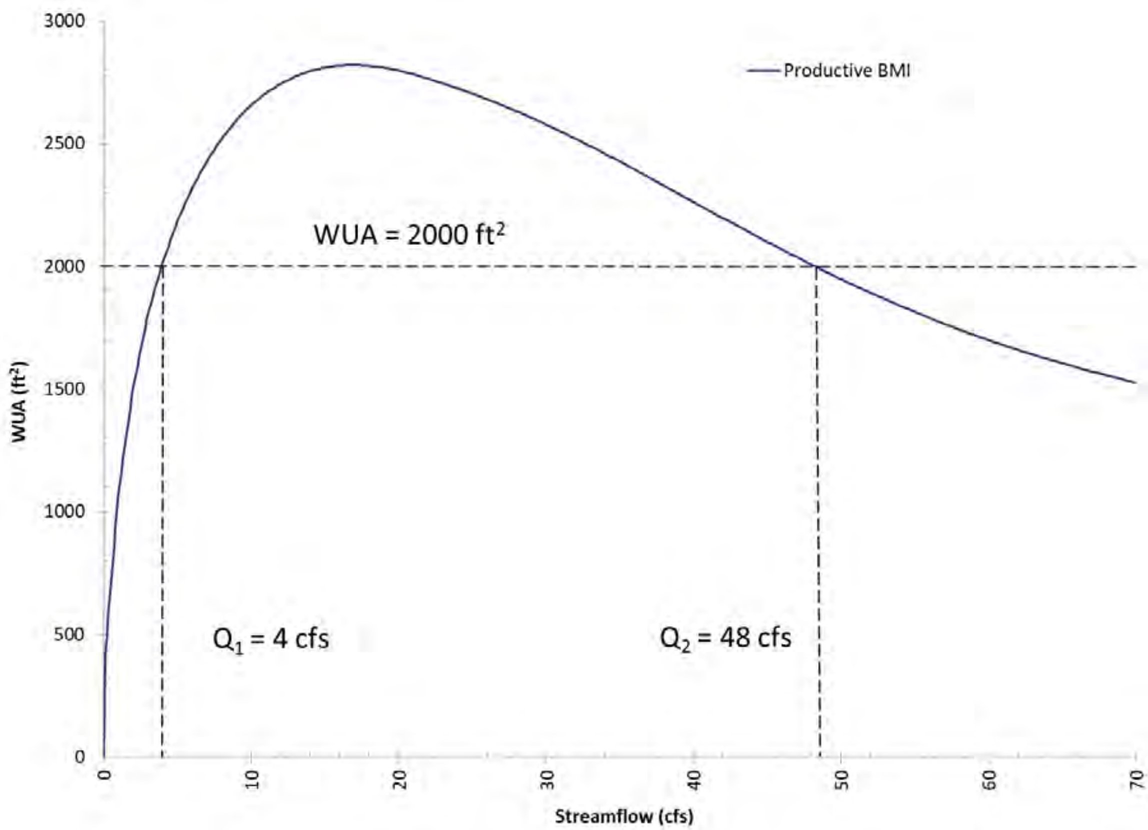


Figure G-30. Example of a single WUA value that corresponds to two streamflow values on the riffles-only WUA curve for productive BMI (extracted from Figure G-6).

The final results of the time-series analysis method are the streamflow values associated with median WUA for each month, summarized by water year class and targeted species and life stages. These streamflow values are representative of a baseline quantity of habitat area available to targeted species and life stages at each modeling site, accounting for seasonality and based on historic observation. The results of this analysis for Sproul Creek are to be considered when developing instream flow criteria for the study reach that best meet the needs of the targeted species at specific life history times.

3 1-D MODEL TIME-SERIES RESULTS

Upon completion of the 1-D time-series analysis for the Upper South Fork Sproul Creek 1-D modeling site, the results were compiled by water year type, life stage, and month of the year. Results for riffles and pools are shown separately as well as combined for the whole reach (Table G-2 through Table G-6).

Table G-2. Time-series analysis results for Extremely Dry water years using 1-D modeling output.

Extremely Dry Water Year 1-D Model Time-series Flow Results (cfs)										
	Month	**Steelhead Spawning**	**Steelhead Large (2+)**	**Steelhead Small (1+)**	**Steelhead Fry**	**Coho Salmon Spawning**	**Coho Salmon Juvenile**	**Coho Salmon Fry**	**Productive BMI**	**Chinook Salmon Spawning**
Riffles	Oct	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Nov	0.7	0.7	0.7	0.7	0.7	0.7	0.5	0.7	0.7
	Dec	1.1	1.1	1.1	0.7	1.1	0.7	0.5	1.1	1.1
	Jan	5.4	5.4	5.4	10.6	5.0	9.6	5.4	4.1	5.4
	Feb	9.3	12.6	10.6	14.3	6.5	13.9	12.6	4.7	12.6
	Mar	12.7	14.2	12.9	14.2	10.9	14.2	14.2	9.1	13.9
	Apr	5.9	5.9	5.9	6.6	5.9	7.2	5.9	5.9	5.9
	May	3.4	3.4	3.4	1.8	3.4	2.3	3.4	3.4	3.4
	Jun	1.8	1.8	1.8	1.7	1.8	1.7	1.8	1.8	1.8
	Jul	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6
	Aug	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pools	Oct	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Nov	0.7	0.7	0.7	0.7	0.7	0.4	0.7	0.7	0.7
	Dec	1.1	1.1	1.1	0.7	1.1	0.6	1.1	1.1	1.1
	Jan	5.4	5.4	5.4	9.2	5.4	5.4	5.4	4.5	5.4
	Feb	12.4	12.6	12.6	12.9	8.5	12.6	12.6	5.4	12.6
	Mar	13.1	14.2	14.2	14.2	11.8	14.2	14.2	9.7	14.2
	Apr	5.9	5.9	5.9	6.9	5.9	5.9	5.9	5.9	5.9
	May	3.4	3.4	3.4	6.5	3.4	3.4	3.4	3.4	3.4
	Jun	1.8	1.8	1.8	1.7	1.8	2.0	1.8	1.8	1.8
	Jul	0.6	0.6	0.6	0.6	0.6	0.4	0.6	0.6	0.6
	Aug	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Whole Reach	Oct	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Nov	0.7	0.7	0.7	0.7	0.7	0.7	0.4	0.7	0.7
	Dec	1.1	1.1	1.1	0.7	1.1	0.6	1.1	1.1	1.1
	Jan	5.4	5.4	5.4	10.2	5.4	5.4	5.4	4.3	5.4
	Feb	11.4	12.6	12.6	13.9	7.7	12.6	12.6	5.1	12.6
	Mar	12.9	14.2	13.4	14.2	11.6	14.2	14.2	9.4	14.2
	Apr	5.9	5.9	5.9	6.8	5.9	5.9	5.9	5.9	5.9
	May	3.4	3.4	3.4	2.0	3.4	3.4	3.4	3.4	3.4
	Jun	1.8	1.8	1.8	1.7	1.8	0.7	1.8	1.8	1.8
	Jul	0.6	0.6	0.6	0.6	0.6	0.6	0.3	0.6	0.6
	Aug	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table G-3. Time-series analysis results for Dry water years using the 1-D modeling output.

Dry Water Year 1-D Model Time-series Flow Results (cfs)										
	Month	**Steelhead Spawning**	**Steelhead Large (2+)**	**Steelhead Small (1+)**	**Steelhead Fry**	**Coho Salmon Spawning**	**Coho Salmon Juvenile**	**Coho Salmon Fry**	**Productive BMI**	**Chinook Salmon Spawning**
Riffles	Oct	0.4	0.4	0.4	0.4	0.4	0.3	0.1	0.4	0.4
	Nov	2.8	2.8	2.8	1.0	2.8	9.2	2.8	2.1	2.8
	Dec	10.9	15.4	11.3	15.4	9.1	15.4	15.4	7.4	13.9
	Jan	9.4	11.1	10.6	11.3	8.6	11.1	11.1	7.5	11.1
	Feb	10.5	14.0	10.7	14.0	9.0	14.0	14.0	7.7	13.9
	Mar	11.5	14.4	11.5	14.4	9.9	14.4	14.4	8.2	13.9
	Apr	7.5	7.5	7.5	7.5	7.2	7.5	7.5	6.8	7.5
	May	2.9	2.9	2.9	3.4	2.9	2.8	2.9	2.9	2.9
	Jun	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.3	1.3
	Jul	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Aug	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pools	Oct	0.4	0.4	0.4	0.3	0.4	0.2	0.4	0.4	0.4
	Nov	2.8	2.8	2.8	9.2	2.8	2.8	2.8	2.8	2.8
	Dec	12.4	15.4	15.0	15.4	10.2	15.4	15.4	7.9	15.4
	Jan	11.1	11.1	11.1	11.1	9.2	11.1	11.1	7.9	11.1
	Feb	12.4	14.0	14.0	14.0	10.1	14.0	14.0	8.3	14.0
	Mar	12.4	14.4	14.3	14.4	10.8	14.4	14.4	8.6	14.4
	Apr	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.1	7.5
	May	2.9	2.9	2.9	5.2	2.9	2.9	2.9	2.9	2.9
	Jun	1.3	1.3	1.3	1.3	1.3	1.5	1.3	1.3	1.3
	Jul	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Aug	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Whole Reach	Oct	0.4	0.4	0.4	0.3	0.4	0.3	0.1	0.4	0.4
	Nov	2.8	2.8	2.8	9.2	2.8	2.9	2.8	2.8	2.8
	Dec	11.4	15.4	13.4	15.4	9.8	15.4	15.4	7.7	15.4
	Jan	11.1	11.1	11.1	11.1	9.2	11.1	11.1	7.9	11.1
	Feb	11.4	14.0	13.4	14.0	9.7	14.0	14.0	8.3	14.0
	Mar	11.7	14.4	13.4	14.4	10.5	14.4	14.4	8.6	14.3
	Apr	7.5	7.5	7.5	7.5	7.4	7.5	7.5	6.9	7.5
	May	2.9	2.9	2.9	2.6	2.9	2.9	2.9	2.9	2.9
	Jun	1.3	1.3	1.3	1.3	1.3	1.5	1.3	1.3	1.3
	Jul	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Aug	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table G-4. Time-series analysis results for Normal water years using the 1-D modeling output.

Normal Water Year 1-D Model Time-series Flow Results (cfs)										
	Month	**Steelhead Spawning**	**Steelhead Large (2+)**	**Steelhead Small (1+)**	**Steelhead Fry**	**Coho Salmon Spawning**	**Coho Salmon Juvenile**	**Coho Salmon Fry**	**Productive BMI**	**Chinook Salmon Spawning**
Riffles	Oct	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Nov	1.7	1.7	1.7	1.0	1.7	8.4	1.8	1.7	1.7
	Dec	13.8	20.9	14.2	25.7	8.9	25.5	18.3	6.3	16.1
	Jan	14.2	20.9	14.4	45.2	8.4	45.2	18.5	4.3	16.2
	Feb	17.2	21.1	17.2	28.0	13.4	27.9	18.5	9.4	17.9
	Mar	18.6	21.1	18.1	23.8	14.9	23.8	18.5	10.4	18.7
	Apr	9.9	10.0	10.0	10.0	9.2	10.0	10.0	7.9	10.0
	May	3.7	3.7	3.7	3.8	3.7	2.6	3.8	3.7	3.7
	Jun	1.7	1.7	1.7	1.4	1.7	1.3	1.7	1.7	1.7
	Jul	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.8	0.8
	Aug	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Sep	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Pools	Oct	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Nov	1.7	1.7	1.7	1.0	1.7	0.3	1.7	1.7	1.7
	Dec	14.8	18.5	16.4	25.5	11.2	25.5	25.5	7.1	23.1
	Jan	15.1	18.6	16.8	38.7	11.5	45.2	45.2	5.7	23.1
	Feb	17.2	20.2	18.8	27.9	14.4	27.9	28.0	10.2	23.1
	Mar	18.3	20.4	19.3	22.5	15.7	23.8	23.8	11.2	23.1
	Apr	10.0	10.0	10.0	10.0	9.9	10.0	10.0	8.3	10.0
	May	3.7	3.7	3.7	2.5	3.7	3.8	3.7	3.7	3.7
	Jun	1.7	1.7	1.7	1.4	1.7	1.7	1.7	1.7	1.7
	Jul	0.8	0.8	0.8	0.8	0.8	0.5	0.8	0.8	0.8
	Aug	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Sep	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Whole Reach	Oct	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Nov	1.7	1.7	1.7	1.0	1.7	0.4	1.7	1.7	1.7
	Dec	14.4	19.0	15.7	25.5	10.6	25.5	25.5	6.7	21.0
	Jan	14.7	19.2	15.8	45.2	10.6	45.2	45.2	5.2	21.0
	Feb	17.2	20.3	17.9	27.9	14.0	27.9	28.0	9.9	21.1
	Mar	18.5	20.6	18.8	23.8	15.4	23.8	23.8	10.8	21.1
	Apr	10.0	10.0	10.0	10.0	9.7	10.0	10.0	8.2	10.0
	May	3.7	3.7	3.7	2.5	3.7	3.7	3.7	3.7	3.7
	Jun	1.7	1.7	1.7	1.4	1.7	0.8	1.7	1.7	1.7
	Jul	0.8	0.8	0.8	0.8	0.8	0.6	0.3	0.8	0.8
	Aug	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3
	Sep	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table G-5. Time-series analysis results Wet water years using the 1-D modeling output.

Wet Water Year 1-D Model Time-series Flow Results (cfs)										
	Month	**Steelhead Spawning**	**Steelhead Large (2+)**	**Steelhead Small (1+)**	**Steelhead Fry**	**Coho Salmon Spawning**	**Coho Salmon Juvenile**	**Coho Salmon Fry**	**Productive BMI**	**Chinook Salmon Spawning**
Riffles	Oct	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Nov	2.6	2.6	2.6	0.8	2.6	0.7	2.6	2.1	2.6
	Dec	10.8	20.9	11.2	30.9	8.0	30.9	18.5	5.5	13.9
	Jan	14.8	20.9	14.9	30.0	10.8	30.0	18.5	7.5	15.7
	Feb	13.6	20.9	14.2	25.2	9.7	25.2	18.5	7.4	15.4
	Mar	15.4	20.9	15.4	33.1	10.6	33.1	18.5	6.9	16.9
	Apr	15.1	16.3	15.2	16.4	13.3	16.4	16.4	10.0	15.4
	May	5.2	5.2	5.2	5.2	5.2	6.8	5.2	5.2	5.2
	Jun	2.3	2.3	2.3	3.7	2.3	2.2	2.3	2.3	2.3
	Jul	1.0	1.0	1.0	1.0	1.0	1.0	1.3	1.0	1.0
	Aug	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	Sep	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Pools	Oct	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Nov	2.6	2.6	2.6	0.6	2.6	3.0	2.6	2.6	2.6
	Dec	12.4	17.9	15.0	30.9	10.1	30.9	30.9	6.3	23.1
	Jan	15.2	17.9	16.0	29.0	12.3	30.0	30.0	8.3	23.1
	Feb	14.4	17.9	15.9	25.2	11.6	25.1	25.1	8.0	23.1
	Mar	15.9	19.2	17.9	33.1	12.5	33.1	33.1	7.8	23.1
	Apr	15.2	16.4	15.6	16.4	13.9	16.4	16.4	10.9	16.4
	May	5.2	5.2	5.2	5.7	5.2	5.2	5.2	5.2	5.2
	Jun	2.3	2.3	2.3	2.2	2.3	2.3	2.3	2.3	2.3
	Jul	1.0	1.0	1.0	1.0	1.0	1.5	1.0	1.0	1.0
	Aug	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	Sep	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Whole Reach	Oct	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Nov	2.6	2.6	2.6	0.7	2.6	0.3	2.6	2.6	2.6
	Dec	11.5	18.9	13.4	30.9	9.5	30.9	30.9	5.9	21.0
	Jan	14.9	18.9	15.6	30.0	12.2	30.0	30.0	8.2	21.0
	Feb	14.2	18.9	15.0	25.1	10.9	25.1	25.1	7.9	21.0
	Mar	15.6	20.0	16.8	33.1	12.0	33.1	33.1	7.4	21.0
	Apr	15.2	16.4	15.4	16.4	13.7	16.4	16.4	10.6	16.3
	May	5.2	5.2	5.2	5.5	5.2	5.2	5.2	5.2	5.2
	Jun	2.3	2.3	2.3	2.2	2.3	2.3	2.3	2.3	2.3
	Jul	1.0	1.0	1.0	1.0	1.0	1.5	0.3	1.0	1.0
	Aug	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4
	Sep	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table G-6. Time-series analysis results for Extremely Wet water years using 1-D modeling output.

Extremely Wet Water Year 1-D Model Time-series Flow Results (cfs)										
	Month	**Steelhead Spawning**	**Steelhead Large (2+)**	**Steelhead Small (1+)**	**Steelhead Fry**	**Coho Salmon Spawning**	**Coho Salmon Juvenile**	**Coho Salmon Fry**	**Productive BMI**	**Chinook Salmon Spawning**
Riffles	Oct	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.5
	Nov	5.9	5.9	5.9	1.0	5.0	8.7	5.9	2.6	5.9
	Dec	9.3	20.9	10.6	41.3	6.9	41.2	18.5	4.8	13.9
	Jan	9.8	20.9	10.8	52.9	6.7	52.9	18.5	3.2	13.9
	Feb	9.8	20.9	10.7	47.0	6.9	47.1	18.5	4.1	13.9
	Mar	13.5	20.9	14.0	37.4	10.1	37.4	18.5	6.2	15.4
	Apr	13.6	18.2	14.0	18.2	11.2	18.2	18.0	9.6	15.0
	May	5.9	5.9	5.9	5.9	5.9	6.6	5.9	5.9	5.9
	Jun	2.5	2.5	2.5	2.0	2.5	2.5	2.5	2.5	2.5
	Jul	1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.1	1.1
	Aug	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Sep	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Pools	Oct	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.5
	Nov	5.9	5.9	5.9	8.7	5.9	5.9	5.9	3.6	5.9
	Dec	12.4	17.9	15.0	38.2	8.7	41.2	41.2	5.5	23.1
	Jan	12.4	17.9	15.0	39.0	9.1	52.9	52.9	4.8	23.1
	Feb	12.4	17.9	15.0	39.0	9.1	47.0	47.0	5.1	23.1
	Mar	14.6	17.9	15.8	37.4	11.9	37.4	37.4	7.7	23.1
	Apr	14.2	17.9	15.4	18.2	12.3	18.2	18.2	9.9	18.2
	May	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
	Jun	2.5	2.5	2.5	2.3	2.5	2.5	2.5	2.5	2.5
	Jul	1.1	1.1	1.1	1.1	1.1	1.5	1.1	1.1	1.1
	Aug	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Sep	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Whole Reach	Oct	0.5	0.5	0.5	0.5	0.5	2.9	0.2	0.5	0.5
	Nov	5.9	5.9	5.9	1.0	5.9	5.9	5.9	3.1	5.9
	Dec	11.4	18.9	13.4	41.2	8.0	41.3	41.3	5.2	21.0
	Jan	11.4	18.9	13.4	47.7	8.5	52.9	52.9	4.4	21.0
	Feb	11.4	18.9	13.4	46.9	8.3	47.0	47.0	4.9	21.0
	Mar	14.4	18.9	15.1	37.4	11.3	37.4	37.4	7.2	21.0
	Apr	14.0	18.2	14.7	18.2	12.2	18.2	18.2	9.7	18.2
	May	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
	Jun	2.5	2.5	2.5	2.3	2.5	2.5	2.5	2.5	2.5
	Jul	1.1	1.1	1.1	1.1	1.1	1.5	1.1	1.1	1.1
	Aug	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Sep	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

4 2-D MODEL TIME-SERIES RESULTS

Upon completion of the 2-D time-series analysis for the Upper Mainstem Sproul Creek site, the results were compiled by water year type, life stage, and month of the year. In addition, results are presented for the entire 2-D reach with and without distance to cover included (Table G-7 through Table G-11).

Table G-7. Time-series analysis results for Extremely Dry water years using the 2-D modeling output.

Extremely Dry Water Year 2-D Model Time-series Flow Results (cfs)										
	Month	**Steelhead Spawning**	**Steelhead Large (2+)**	**Steelhead Small (1+)**	**Steelhead Fry**	**Coho Salmon Spawning**	**Coho Salmon Juvenile**	**Coho Salmon Fry**	**Productive BMI**	**Chinook Salmon Spawning**
Depth, Velocity, and Distance to Cover	Oct	0.5	0.5	0.5	1.1	0.5	0.8	0.1	0.5	0.5
	Nov	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Dec	3.6	3.6	3.6	2.0	3.6	2.2	3.6	3.6	3.2
	Jan	11.7	14.9	13.2	19.0	9.4	22.1	18.3	14.7	7.3
	Feb	13.0	18.2	14.6	42.9	10.5	42.9	42.9	16.2	8.4
	Mar	25.7	33.5	29.3	48.2	19.6	48.2	48.2	30.4	12.8
	Apr	19.4	19.9	19.6	19.9	18.8	19.9	19.9	19.9	17.8
	May	11.5	11.7	11.7	11.7	11.1	16.6	11.7	11.8	10.6
	Jun	6.3	6.3	6.3	8.9	6.3	5.8	6.3	6.3	6.3
	Jul	2.2	2.2	2.2	2.5	2.2	2.2	2.2	2.2	2.2
	Aug	0.2	0.2	0.2	1.6	0.2	0.8	0.1	0.2	0.2
	Sep	0.1	0.1	0.1	1.0	0.1	0.8	0.0	0.1	0.1
Depth and Velocity	Oct	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Nov	2.5	2.5	2.5	2.4	2.5	2.5	2.7	2.5	2.5
	Dec	3.6	3.6	3.6	1.9	3.6	2.0	3.6	3.6	3.2
	Jan	11.7	13.8	13.1	20.4	9.4	20.4	20.4	14.7	7.3
	Feb	13.0	15.7	14.1	43.7	10.5	43.7	42.9	16.2	8.4
	Mar	25.7	30.9	28.9	48.2	19.6	48.2	48.2	30.4	12.8
	Apr	19.4	19.9	19.6	19.9	18.8	19.9	19.9	19.9	17.8
	May	11.5	11.7	11.7	11.7	11.1	11.7	11.8	11.8	10.6
	Jun	6.3	6.3	6.3	7.3	6.3	9.9	6.3	6.3	6.3
	Jul	2.2	2.2	#N/A	7.7	2.2	2.2	3.1	2.2	2.2
	Aug	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.2
	Sep	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1

Table G-8. Time-series analysis results for Dry water years using the 2-D modeling output.

Dry Water Year 2-D Model Time-series Flow Results (cfs)										
	Month	**Steelhead Spawning**	**Steelhead Large (2+)**	**Steelhead Small (1+)**	**Steelhead Fry**	**Coho Salmon Spawning**	**Coho Salmon Juvenile**	**Coho Salmon Fry**	**Productive BMI**	**Chinook Salmon Spawning**
Depth, Velocity, and Distance to Cover	Oct	1.5	1.5	1.5	2.3	1.5	0.9	1.5	1.5	1.5
	Nov	7.7	9.4	7.1	11.9	5.8	19.2	9.4	9.4	5.0
	Dec	21.2	27.2	24.0	52.3	14.9	52.3	52.3	25.2	10.3
	Jan	23.9	27.1	25.1	37.7	22.0	37.7	37.7	25.6	18.0
	Feb	21.8	28.3	24.6	47.6	17.8	47.6	47.6	25.8	14.7
	Mar	24.6	29.7	26.9	49.0	20.9	49.0	49.0	27.4	15.7
	Apr	21.8	24.1	22.8	25.6	19.9	25.6	25.6	23.3	18.8
	May	9.9	9.9	9.9	9.9	9.9	8.4	9.9	9.9	9.9
	Jun	4.3	4.4	4.4	4.1	4.3	4.4	4.4	4.3	4.3
	Jul	1.8	1.8	1.8	2.0	1.8	1.8	1.8	1.8	1.8
	Aug	0.5	0.5	0.5	0.8	0.5	0.8	0.2	0.5	0.5
	Sep	0.1	0.1	0.1	0.8	0.1	0.8	0.1	0.1	0.1
Depth and Velocity	Oct	1.5	1.5	1.5	0.8	1.5	0.8	0.5	1.5	1.5
	Nov	7.7	9.4	6.7	9.9	5.8	11.4	9.4	9.4	5.0
	Dec	21.2	25.6	23.6	52.3	14.9	52.3	52.3	25.2	10.3
	Jan	23.9	26.3	25.1	37.7	22.0	37.7	37.7	25.6	18.0
	Feb	21.8	26.6	24.0	47.6	17.8	47.6	47.6	25.8	14.7
	Mar	24.6	28.3	26.2	48.9	20.9	48.9	49.0	27.4	15.7
	Apr	21.8	23.5	22.7	25.6	19.9	25.6	25.6	23.3	18.8
	May	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9
	Jun	4.3	4.3	4.3	5.9	4.3	4.3	4.4	4.3	4.3
	Jul	1.8	1.8	1.8	1.8	1.8	1.8	2.1	1.8	1.8
	Aug	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Sep	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1

Table G-9. Time-series analysis results for Normal water years using the 2-D modeling output.

Normal Water Year 2-D Model Time-series Flow Results (cfs)										
	Month	**Steelhead Spawning**	**Steelhead Large (2+)**	**Steelhead Small (1+)**	**Steelhead Fry**	**Coho Salmon Spawning**	**Coho Salmon Juvenile**	**Coho Salmon Fry**	**Productive BMI**	**Chinook Salmon Spawning**
Depth, Velocity, and Distance to Cover	Oct	0.4	0.4	0.4	2.3	0.4	0.4	0.0	0.4	0.4
	Nov	5.8	5.8	5.8	12.6	5.5	2.4	5.8	5.8	4.8
	Dec	110.7	137.4	120.1	86.7	105.2	86.7	86.7	125.9	93.2
	Jan	153.6	160.6	153.6	153.6	153.5	153.6	153.5	157.7	153.5
	Feb	95.0	105.1	95.0	95.0	95.0	95.0	95.0	95.9	95.0
	Mar	83.2	97.3	87.3	80.9	80.8	80.8	80.8	88.2	80.9
	Apr	23.0	28.5	25.6	34.0	20.6	34.0	34.0	26.2	17.8
	May	12.6	12.8	12.6	12.8	12.6	7.3	12.8	12.7	12.0
	Jun	5.8	5.8	5.8	3.6	5.8	4.2	5.8	5.8	5.8
	Jul	2.6	2.6	2.6	2.3	2.6	2.5	2.6	2.6	2.6
	Aug	1.0	1.0	1.0	2.3	1.0	1.0	0.0	1.0	1.0
	Sep	0.5	0.5	0.5	0.9	0.5	0.5	0.0	0.5	0.5
Depth and Velocity	Oct	0.4	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.4
	Nov	5.8	5.8	5.8	9.4	5.5	1.6	6.8	5.8	4.8
	Dec	110.7	127.2	117.5	86.6	105.2	86.7	86.6	125.9	93.2
	Jan	153.6	156.2	153.6	153.6	153.5	153.6	153.5	157.7	153.5
	Feb	95.0	98.3	95.0	95.0	95.0	95.0	123.8	95.9	95.0
	Mar	83.2	92.0	86.4	80.8	80.8	80.8	80.8	88.2	80.9
	Apr	23.0	26.7	25.1	34.0	65.8	34.0	34.0	26.2	17.8
	May	12.6	12.6	12.6	12.8	12.6	12.8	12.8	12.7	12.0
	Jun	5.8	5.8	5.8	6.8	5.8	3.8	5.8	5.8	5.8
	Jul	2.6	2.6	2.6	1.9	2.6	2.3	2.7	2.6	2.6
	Aug	1.0	1.0	1.0	1.0	1.0	1.0	3.4	1.0	1.0
	Sep	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table G-10. Time-series analysis results for Wet water years using the 2-D modeling output.

Wet Water Year 2-D Model Time-series Flow Results (cfs)										
	Month	**Steelhead Spawning**	**Steelhead Large (2+)**	**Steelhead Small (1+)**	**Steelhead Fry**	**Coho Salmon Spawning**	**Coho Salmon Juvenile**	**Coho Salmon Fry**	**Productive BMI**	**Chinook Salmon Spawning**
Depth, Velocity, and Distance to Cover	Oct	0.4	0.4	0.4	0.7	0.4	0.4	0.1	0.4	0.4
	Nov	7.7	8.9	7.1	1.6	5.5	1.8	8.9	8.9	4.5
	Dec	129.8	148.7	133.5	105.2	121.4	105.2	118.8	136.6	116.7
	Jan	102.1	120.4	123.1	102.1	102.1	102.1	102.1	111.0	102.1
	Feb	94.0	126.1	106.8	85.5	85.5	85.5	85.5	111.8	85.5
	Mar	112.5	127.1	114.6	112.5	112.5	112.5	115.7	118.3	112.5
	Apr	81.7	99.7	86.4	55.7	70.4	55.7	55.8	89.1	59.4
	May	17.3	17.8	17.3	17.8	17.3	17.8	17.8	17.8	16.2
	Jun	7.9	7.9	7.9	3.7	7.9	6.8	7.9	7.9	7.9
	Jul	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
	Aug	1.5	1.5	1.5	1.6	1.5	1.5	1.5	1.5	1.5
	Sep	0.3	0.3	0.3	0.7	0.3	0.3	0.2	0.3	0.3
Depth and Velocity	Oct	0.4	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.4
	Nov	7.7	8.9	6.8	0.9	5.5	0.9	10.2	8.9	4.5
	Dec	129.8	136.6	131.9	105.2	121.4	105.2	116.7	136.6	116.7
	Jan	102.1	114.6	106.8	102.1	102.1	102.1	123.0	111.0	102.1
	Feb	94.0	115.6	106.0	85.5	85.5	85.6	85.5	111.8	85.5
	Mar	112.5	119.9	113.6	112.5	112.5	112.5	128.8	118.3	112.5
	Apr	81.7	93.4	85.2	55.7	70.4	55.7	55.8	89.1	59.4
	May	17.3	17.8	17.3	17.8	17.3	17.8	17.8	17.8	16.2
	Jun	7.9	7.9	7.9	7.9	7.9	8.9	7.9	7.9	7.9
	Jul	3.5	3.5	3.5	3.4	3.5	3.5	3.5	3.5	3.5
	Aug	1.5	1.5	1.5	1.5	1.5	1.5	1.9	1.5	1.5
	Sep	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.3

Table G-11. Time-series analysis results for Extremely Wet water years using the 2-D modeling output.

Extremely Wet Water Year 2-D Model Time-series Flow Results (cfs)										
	Month	**Steelhead Spawning**	**Steelhead Large (2+)**	**Steelhead Small (1+)**	**Steelhead Fry**	**Coho Salmon Spawning**	**Coho Salmon Juvenile**	**Coho Salmon Fry**	**Productive BMI**	**Chinook Salmon Spawning**
Depth, Velocity, and Distance to Cover	Oct	1.8	1.8	1.8	1.8	1.8	1.7	1.8	1.8	1.8
	Nov	8.3	14.5	8.3	19.9	6.8	20.4	19.9	12.8	6.3
	Dec	140.3	163.7	140.3	140.3	140.3	140.3	140.3	149.0	140.3
	Jan	179.7	180.3	179.7	179.7	179.7	179.7	179.7	179.7	179.7
	Feb	159.9	172.0	159.9	159.9	159.9	159.9	159.9	159.9	159.9
	Mar	127.2	130.0	127.2	127.2	127.2	127.2	127.2	127.2	127.2
	Apr	78.6	109.1	89.4	61.8	66.4	61.8	61.8	91.7	62.3
	May	19.4	19.9	19.9	19.9	18.8	19.9	19.9	19.9	18.3
	Jun	8.4	8.4	8.4	8.4	8.4	7.3	8.4	8.4	8.4
	Jul	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	Aug	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	Sep	0.5	0.5	0.5	1.0	0.5	0.4	0.2	0.5	0.5
Depth and Velocity	Oct	1.8	1.8	1.8	1.5	1.8	1.6	3.1	1.8	1.8
	Nov	8.3	10.4	8.1	19.9	6.8	19.9	19.9	12.8	6.3
	Dec	140.3	146.7	140.3	140.3	140.3	140.3	140.9	149.0	140.3
	Jan	179.7	179.7	179.7	179.7	179.7	179.7	179.7	179.7	179.7
	Feb	159.9	159.9	159.9	159.9	159.9	159.9	159.9	159.9	159.9
	Mar	127.2	127.4	127.2	127.2	127.2	127.2	135.4	127.2	127.2
	Apr	26.2	33.0	87.9	61.8	66.4	61.8	61.8	91.7	62.3
	May	19.4	19.9	19.9	19.9	18.8	19.9	19.9	19.9	18.3
	Jun	8.4	8.4	8.4	8.4	8.4	8.9	8.4	8.4	8.4
	Jul	3.8	3.8	3.8	3.5	3.8	3.8	3.8	3.8	3.8
	Aug	1.6	1.6	1.6	1.6	1.6	1.6	2.0	1.6	1.6
	Sep	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

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