



— BUREAU OF —  
RECLAMATION

# **Technical Memorandum**

## **Modified Flows 2020, Yakima River Basin**

**Columbia Pacific Northwest Region**

## **Mission Statements**

The Department of the Interior conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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# Acronyms and Abbreviations

Acronym or Abbreviation	Definition
AF	Acre-feet
AMRW	American River near Nile, Washington
ANSW	Anderson Diversion
AUGW	Ahtanum Creek near Union Gap, Washington
BLEW	Blue Slough Diversion
BOCW	Boise Cascade Diversion
BPA	Bonneville Power Administration
BUCW	Bull Diversion
BUM	Bumping Reservoir
CACW	Cascade Gravity above Slide Diversion
CADW	Cascade Pumps below Slide Diversion
CAPW	Carmack Parker Diversion
CCEW	City of Cle Elum Municipal and Industrial Diversions
CELW	City of Ellensburg Municipal and Industrial Diversions
cfs	Cubic feet per second
CHCW	Chandler Canal Diversion
CHFW	Chapman Nelson Diversion
CLCW	Clark Diversion
CLE	Cle Elum Reservoir
CLFW	Naches River near Cliffdell, Washington
COBW	Cobb Upper Diversion
CODW	Congdon Diversion
Corps	U.S. Army Corps of Engineers
CUMW	Columbia Canal Diversion
CYDW	City of Yakima Municipal and Industrial Diversions
CYIW	City of Yakima Irrigation Diversion
EASW	Yakima River at Easton, Washington
ELFW	Ellensburg Mill and Feed Diversion
ELPW	Ellensburg Power Diversion

Acronym or Abbreviation	Definition
ELTW	Ellensburg Town Diversion
EMKW	Emerick Diversion
FAHW	Fredricks Hunting Diversion
FOGW	Fogarty Dyer Diversion
FOTW	Foster Naches Diversion
FRUW	Fruitvale Diversion
GLEW	Gleed Diversion
HUBW	Hubard Diversion
KAC	Kachess Reservoir
KEE	Keechelus Reservoir
KIAW	Kiona Canal Diversion
KIOW	Yakima River at Kiona, Washington
KLYW	Kelly Lowry Diversion
KNCW	Kennewick Canal Diversion
KNOW	Knoke Diversion
KTCW	Kittitas Diversion
MISW	Mills and Son Diversion
MOEW	Morrissey Diversion
MOXW	Moxee Diversion
NACW	Naches River near Naches, Washington
NCOW	Naches Cowiche Diversion
NIVW	Nile Valley Diversion
NSCW	Naches Selah
OCCW	O'Conner Diversion
OLDW	Old Union Diversion
PARW	Yakima River near Parker, Washington
Reclamation	Bureau of Reclamation
RIM	Rimrock Reservoir
RINW	Richland Canal Diversion
RIZW	Richartz Diversion
RSCW	Reservation New Diversion
RSDW	Reservation Old Diversion

Acronym or Abbreviation	Definition
RZCW	Roza Diversion
SADW	Stanfield Diversion
SEXW	Selah Moxee Diversion
SINW	Sinclair Diversion
SNCW	Sunnyside Diversion
SOUW	South Naches Diversion
STCW	Stevens Diversion
TIEW	Tieton Diversion
TITW	Tenant Diversion
TOEW	Tiossem Diversion
TORW	Taylor Diversion
UMTW	Yakima River near Umtanum, Washington
UNGW	Union Gap Diversion
VESW	Vertrees 2
VETW	Vertrees 1 Diversion
WESW	Westside Diversion
WOIW	Wapatox Irrigation Diversion
WOLW	Woldale Diversion
WOPW	Wapatox Power Diversion
YGVW	Yakima River at Euclid Road bridge near Grandview, Washington
YOUW	Younger Diversion
YRPW	Yakima River near Prosser, Washington
YUMW	Yakima River at Cle Elum, Washington

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# 1. Introduction

Modified Flows, as computed by the Bureau of Reclamation (Reclamation), are the historical unregulated streamflows from 1928 through 2018 adjusted to reflect what would have occurred with 2020 level reservoir regulation and 2020 level demands. Reclamation produces these flows for the Deschutes, Upper Snake, and Yakima river systems and provides the data to Bonneville Power Administration (BPA) for use in Columbia River System models.

The Modified Flows produced by Reclamation are different from the Modified Flows produced by the U.S. Army Corps of Engineers (Corps) and BPA for other parts of the Columbia System. For inputs other than from the Deschutes, Upper Snake, and Yakima, the Corps and BPA use streamflows that would have been observed if current irrigation depletions (as of year 2018) existed in the past and if the effects of river regulation were removed; for these locations, these flows are also termed Modified Flows. Stated another way, Modified Flows from the Corps and BPA differ from those produced by Reclamation in that the Corps/BPA Modified Flows are unregulated and Reclamation's are regulated; both sets are adjusted for the influence of irrigation.

Modified flows quantified in the Pacific Northwest by the Corps, BPA and Reclamation are used together as baseline streamflows for analysis of future conditions, such as changes to the Federal Columbia River Power System due to operational or climatic changes.

This report describes the data, models, and processes that were used to develop the 2020 level Modified Streamflows for the Yakima River. Figure 1 shows a map of the basin and the included tributaries.

## 1.1. Reclamation Modified Flows Process

Modified Flows in the Deschutes, Upper Snake, and Yakima river basins are generated using the generalized process outlined below:

1. Unregulated reach gains/losses in the basin are developed using measured historical data. Unregulated flows at gaged locations are developed using these reach gains/losses.
2. A demand pattern for each diversion location is developed to represent current level conditions.
3. The regulation model is updated to include current level reservoir operations.
4. The unregulated reach gains/losses are input into the model along with the current level demand pattern. The output is the Modified Flows dataset.

The details of this process for the Yakima River basin are described in this document.

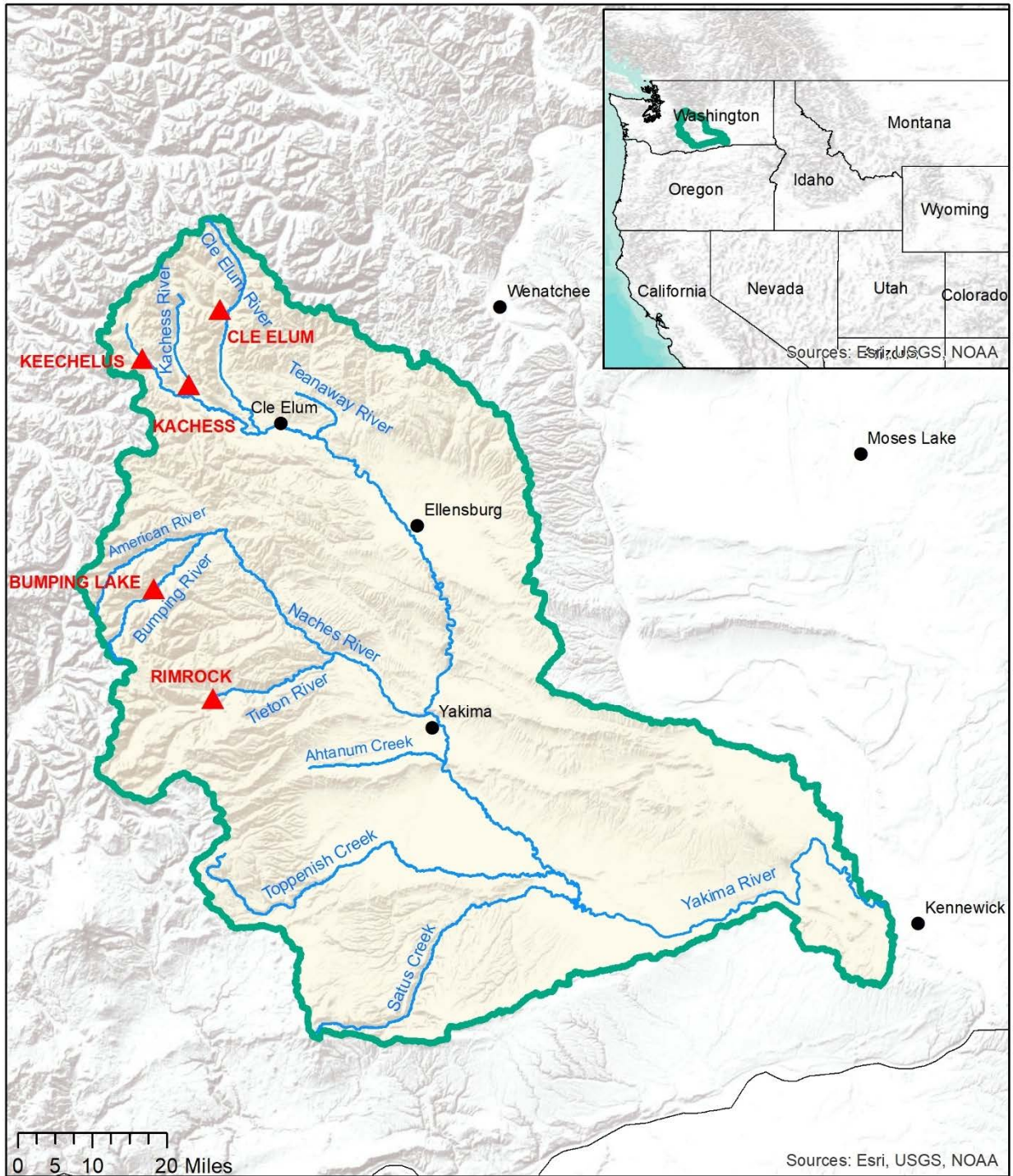


Figure 1. Yakima River basin

## 2. Unregulated Flow Dataset Development

Unregulated flows are the basis for any water resources modeling study because they describe the flow in the system without any influence from regulation activities such as reservoir operation, diversion from the river, or return flow from irrigation activities. The intent of developing unregulated flows is to estimate the natural inflows to the system using measured data from the regulated system.

### 2.1. Unregulated Flows Methodology

Unregulated flows are generally calculated by first calculating reach gains and losses based on mass balance equations that assume that water can neither be created or destroyed. Equation 1 is the generalized equation that is used to calculate gains/losses to a river reach that contains a reservoir, where  $g/l$  is calculated gains and losses,  $o$  is measured outflow,  $i$  is measured inflow,  $d$  is measured diversion,  $r$  is calculated return flows,  $e$  is reservoir evaporation,  $s$  is reservoir seepage,  $p$  is groundwater pumping, and  $\Delta s$  is the change in reservoir storage.

$$g/l = o - i + d - r + e + s + p + \Delta s \quad \text{Equation 1}$$

Equation 2 is the generalized equation that is used to calculate gains/losses to a river reach without a reservoir.

$$g/l = o - i + d - r + p \quad \text{Equation 2}$$

The reach gains and losses are then summed at gage locations to calculate the unregulated flows. A detailed methodology for determining unregulated reach gains and losses can be found in a separate Reclamation 2017<sup>1</sup> report (Reclamation 2017). The equations used to calculate the unregulated gains and losses are included in Appendix A of this report.

In the Yakima basin, additional steps were required to compute unregulated gains/losses given the current structure of the model. The required model input river reach gains/losses were first computed as in Equation 1 at 14 locations within the basin, but this was done without knowledge of the modeled unmeasured diversions and the return flows from all diversions (i.e., terms  $d$  and  $r$  in Equation 1). These gains/losses were input into the RiverWare model, which distributed them into the various tributaries of the basin where additional unmeasured diversion was estimated by the model. The difference between the simulated and measured streamflow was compared and the gains/losses adjusted to compensate for the difference. Steps were then taken to iteratively arrive at the gains and losses while the model recomputed diversions and return flows to an equilibrium state.

- Step 1: The adjusted model input gains/losses were input into the model.

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<sup>1</sup> The referenced document is focused on the Deschutes basin, but the general principles still apply. As mentioned in this document, additional steps are required to compute gains/losses for the Yakima Basin.

- Step 2: The model was run while it distributed the adjusted gains/losses and estimated diversions and calculated return flow, all while holding reservoir outflow constant.
- Step 3: The difference between the simulated streamflow and measured streamflow at each gage was compared to the previous iteration; if the difference was minimal, the adjusted model input gains/losses were considered correct.
- Step 4: Repeated Steps 1-3 until the difference between the simulated streamflow and measured streamflow at each gage between two successive iterations were equal.

## 2.2. Unregulated Flows in the Yakima

Unregulated flows in the Yakima basin were calculated at a daily timestep for the period of October 1, 1926 through September 30, 2018. Figure 2 and Figure 3 show the time series of the daily unregulated flows for gage locations in the Yakima Basin (blue dashed). Monthly average flows were calculated from the daily time series, and the plots show how much the variability was smoothed by the averaging process. The day-to-day variability is larger than the monthly average variability, which can partly be attributed to daily weather events. This can be especially true on reaches with reservoirs where wind and wave activity from boats on the reservoirs can cause changes to the daily measured forebay elevations; small changes in forebay can translate into large variation in storage<sup>2</sup>.

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<sup>2</sup> Reservoir storage is computed from measured forebay elevations.

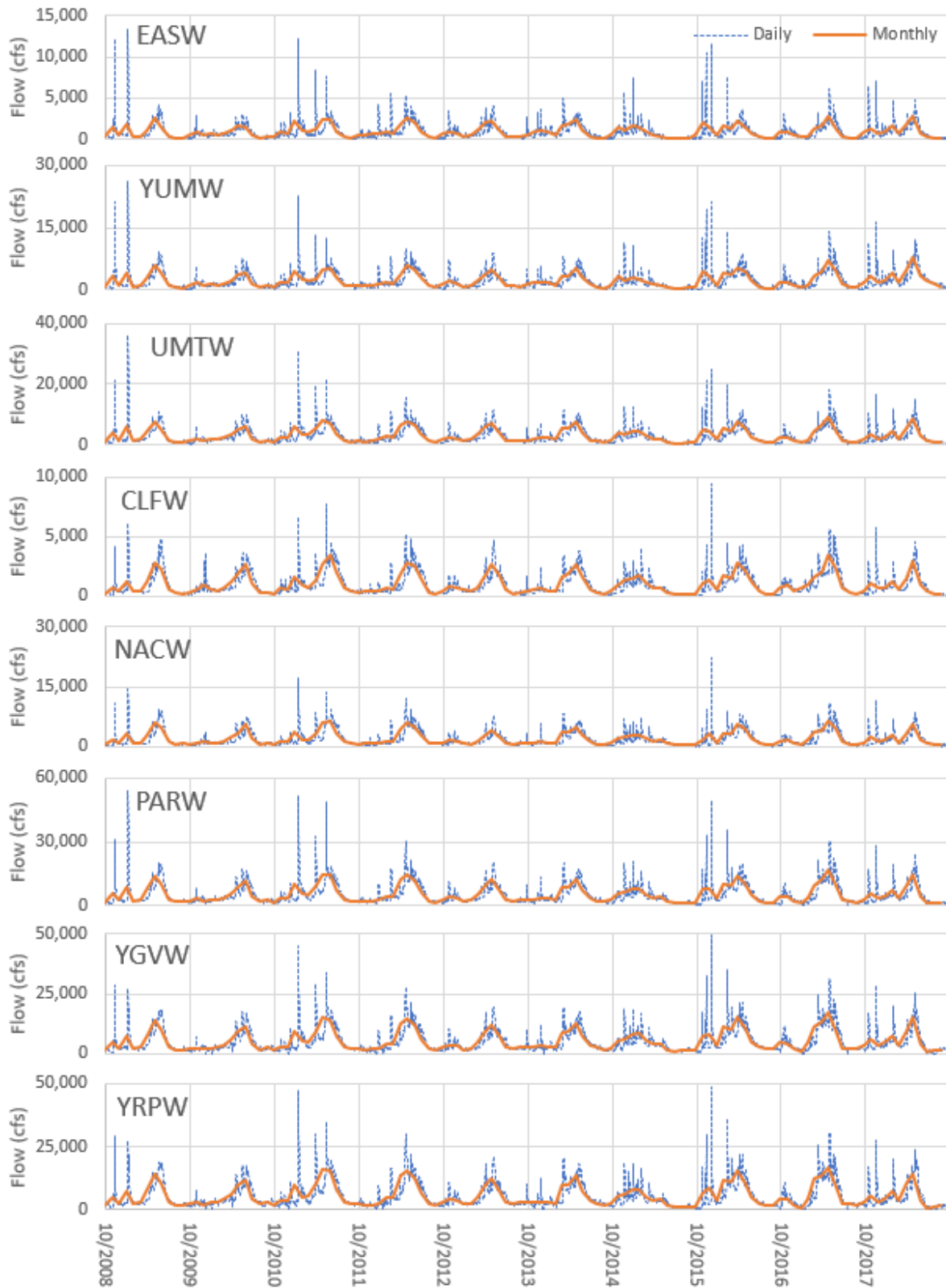


Figure 2. Unregulated flows for the different gages in the Yakima on a daily timestep (blue) and the monthly average of the daily data (orange); first of two groupings of gages

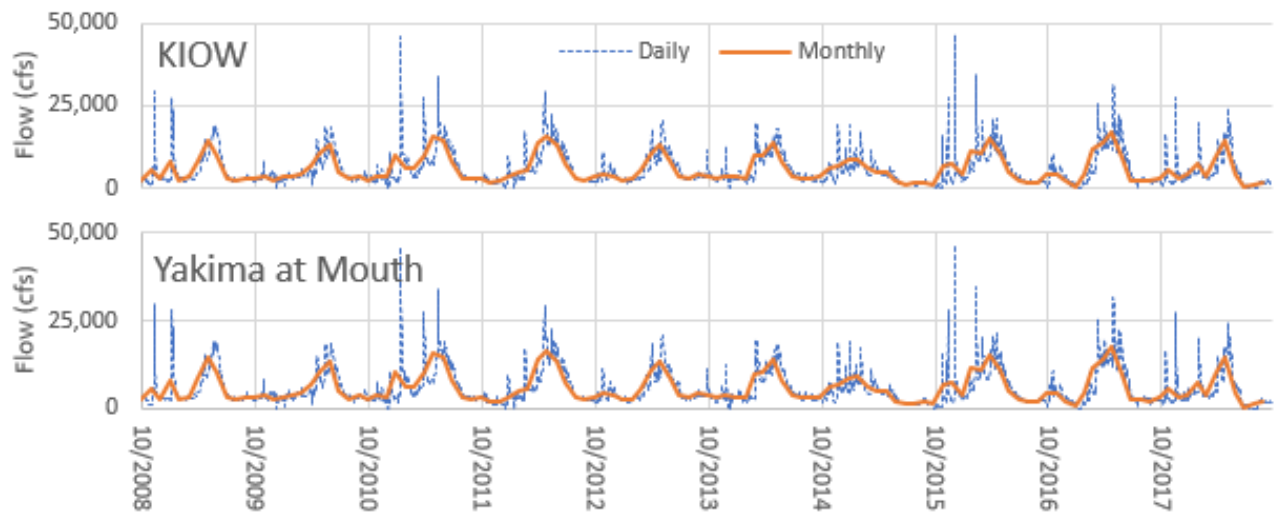


Figure 3. Unregulated flows for the different gages in the Yakima on a daily timestep (blue) and the monthly average of the daily data (orange); second of two groupings of gages

Flows for the Modified Flows studies have historically been provided as the flow of the Yakima River at the mouth. However, there is no gage at this location. In order to represent the flows as they were in the previous Modified Flows version, the flows on the Yakima River at the mouth were represented as the upstream KIW gage with downstream diversions added and downstream return flows subtracted.

Compared to unregulated flows from 2010 (Reclamation 2010), the 2020 unregulated flows were similar. The differences in annual volume and peaks for 2000 to 2009 (the last ten years of overlap in the two datasets) are presented in Table 1. The annual volumes for the 2020 dataset were 5 percent lower than the 2010 dataset on average. The maximum monthly volumes for 2020 were 3 percent lower than the 2010 dataset on average. The minimum monthly volumes were 14 percent lower than the 2010 dataset. The differences are likely due to refinements in the calculation of the unregulated flows including better estimates of unmeasured diversions and return flows.

Table 1. Annual volume comparison for the Yakima River at the mouth, 2020 Unregulated Flows dataset compared to the 2010 Unregulated Flows dataset for years 1999-2008 (the last 10 years of overlap). All volumes are in acre-feet.

Year	Annual Volume		Maximum Monthly Volume		Minimum Monthly Volume	
	2020	2010	2020	2010	2020	2010
1999	5,164,793	5,323,169	1,025,668	1,043,539	115,560	137,058
2000	4,082,997	4,254,713	725,900	725,366	138,620	146,650
2001	1,941,264	2,176,618	457,712	527,571	60,223	85,509
2002	4,188,894	4,309,330	801,481	823,430	108,329	113,877
2003	3,523,432	3,660,702	620,990	583,280	64,748	101,099
2004	3,349,739	3,552,276	526,784	577,131	156,499	176,288
2005	2,355,598	2,549,028	352,864	379,507	90,166	94,754
2006	4,055,202	4,111,748	1,002,016	1,013,085	122,142	112,524
2007	4,270,333	4,504,731	750,153	777,645	77,939	90,265
2008	3,622,924	3,838,481	1,026,116	1,093,819	104,747	127,876
Averages	3,655,517	3,828,079	728,969	754,437	103,897	118,590
% Difference vs. 2010	-5%	--	-3%	--	-14%	--

## 3. Modified Flow Dataset Development

Modified Flows are flows that represent 2020 level reservoir operations and irrigation demand levels throughout the period of record, 1926 through 2018. The Yakima RiverWare model was used to develop the Modified Flows dataset from 1926 through 2018.

### 3.1. Reference RiverWare Model

The water resources modeling for the 2020 Modified Flows study was conducted using a daily timestep RiverWare (Reclamation 2010) model of the Yakima River basin. A short summary of the model is presented here. A complete description of the model development is provided in separate documents (Reclamation 2010; HDR 2017).

The RiverWare model represents the Yakima River basin (Figure 1).

RiverWare is a general rules-based modeling platform that requires full definition of the physical layout of a river system and logic to define operation of the system. The model is constructed using RiverWare objects that define reservoirs, diversions, river reaches, and river gages. Figure 4 diagrams the layout of the RiverWare model for the Yakima River basin. The red circles indicate water users (representing diversions) and are labeled with the river reach or water user acronym that they serve. The orange boxes indicate stream gages and are named with their four-letter parameter code from the Hydromet program (<https://www.usbr.gov/pn/hydromet/>).



# Yakima RiverWare Representation

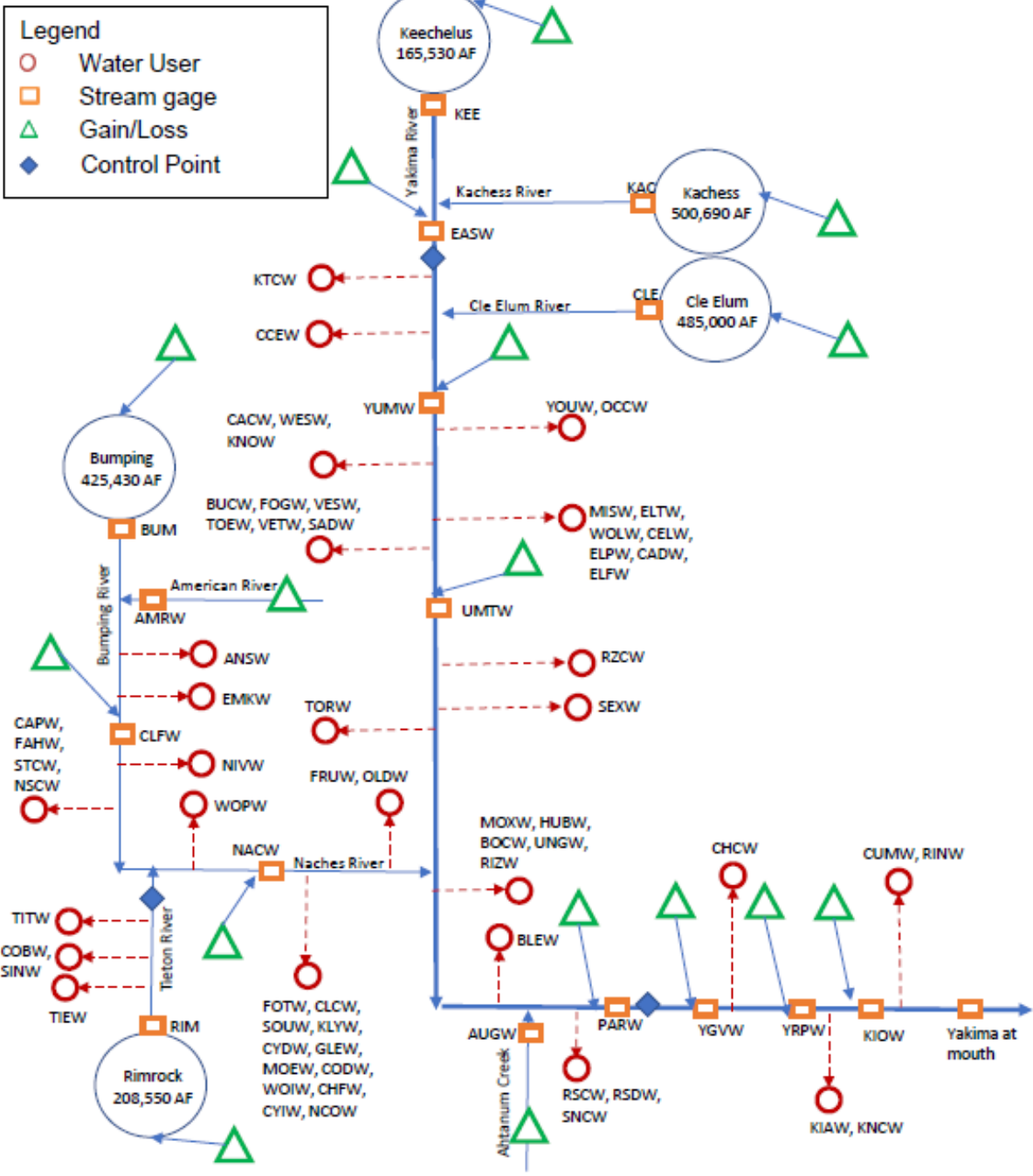


Figure 4. Schematic of RiverWare representation of the Yakima River basin. The green triangles represent locations where gains/losses are input into the model. The blue diamonds represent control points. The model itself includes significantly more detail than this schematic, but the diagram shows the most relevant features of the model.

Operating rule logic was first developed to simulate historical operations from 2005 through 2015, the years in which measured data could be compared to model output to ensure proper operation. The model used diversion patterns and inflow hydrology representative of the time period. Detailed information about the inputs and calibration quality is described in a separate report describing model development and updates (HDR 2017).

It is important to recognize that there are many assumptions and simplifications that are required when developing a model. The data and operating logic attempt to simulate realistic conditions and water management as closely as possible, but there will be some operations that are handled differently in real time.

### 3.2. Irrigation Demand Pattern

The Modified Flows study is designed to represent the response of a system using the current operational rules and demand levels. Demands were changed from the historical daily time series that varies from year-to-year to a yearly pattern that represents average wet irrigation diversions calculated from measured data for recent years (2009 through 2018).

Deliveries are generally prorated to users that have proratable annual entitlements based on the amount of water available. During 100 percent proration years, 85 to 95 percent<sup>3</sup> of user entitlement is supplied to users. Table 2 shows the total proratable and nonproratable annual entitlement volumes and the 2009 through 2018 modeled annual average demand for each water user. Figure 5 shows the sum of the patterns for the Yakima basin for a wet year (2012) where modeled proration was 100 percent, and for a dryer year (2015) where modeled proration was 48 percent.

Table 2. Total annual entitlement and modeled annual average demand per user. The annual average demand was computed from water years 2009 to 2018.

Water User	Annual Entitlement Nonproratable (acre-feet)	Annual Entitlement Proratable (acre-feet)	Average Annual Demand (acre-feet)
Anderson (ANSW)	1,570	0	1,387
Blue Slough (BLEW)	4,245	0	3,750
Boise Cascade (BOCW)	9,159	100	8,172
Bull (BUCW)	6,471	0	5,196
Carmack Parker (CAPW)	639	0	564
Cascade Gravity above Slide (CACW)	0	0	0
Cascade Pumps below Slide (CADW)	49,525	0	39,766

<sup>3</sup> From communication with Chris Lynch (Reclamation), historical deliveries have not historically diverted their full entitlements.

Water User	Annual Entitlement Nonproratable (acre-feet)	Annual Entitlement Proratable (acre-feet)	Average Annual Demand (acre-feet)
Chandler Canal (CHCW)	NA	NA	939,702
Chapman Nelson (CHFW)	7,641	0	6,750
City of Cle Elum M and I (CCEW)	1,260	0	1,012
City of Ellensburg M and I (CELW)	0	6,000	4,353
City of Yakima Irrigation (CYW)	8,805	1,500	8,990
City of Yakima M and I (CYDW)	4,859	4,500	7,927
Clark (CLCW)	4,562	0	4,030
Cobb Upper (COBW)	727	0	642
Columbia Canal (CUMW)	NA	NA	71,490
Congdon (CODW)	23,720	4,305	24,431
Ellensburg Mill and Feed (ELFW)	4,804	0	3,857
Ellensburg Power (ELPW)	6,031	0	4,843
Ellensburg Town (ELTW)	47,758	0	38,347
Emerick (EMKW)	687	0	607
Fogarty Dyer (FOGW)	3,690	0	2,963
Foster Naches (FOTW)	1,150	0	1,334
Fredricks Hunting (FAHW)	950	0	839
Fruitvale (FRUW)	17,708	0	15,643
Gleed (GLEW)	22,819	0	20,158
Hubbard (HUBW)	11,165	0	9,863
Kelly Lowry (KLYW)	8,490	0	7,500
Kennewick Canal (KNCW)	NA	NA	99,052
Kiona Canal (KIAW)	NA	NA	10,220
Knoke (KNOW)	1,600	0	1,285
Kittitas (KTCW)	0	336,000	309,723
Mills and Son (MISW)	7,530	0	6,046
Morrissey (MOEW)	1,206	0	1,065
Moxee (MOXW)	4,245	960	4,525
Naches Cowiche (NCOW)	15,096	0	13,335
Naches Selah (NSCW)	49,658	4,486	47,620
Nile Valley (NIVW)	4,350	0	3,843

Water User	Annual Entitlement Nonproratable (acre-feet)	Annual Entitlement Proratable (acre-feet)	Average Annual Demand (acre-feet)
O'Conner (OCCW)	3,100	0	2,489
Old Union (OLDW)	17,675	0	15,614
Reservation New (RSCW)	305,613	350,000	566,294
Reservation Old (RSDW)	0	0	0
Richartz (RIZW)	6,364	0	5,622
Richland Canal (RINW)	NA	NA	22,604
Roza (RZCW)	0	375,000	878,716
Selah Moxee (SEXW)	27,493	4,281	27,745
Sinclair (SINW)	786	0	694
South Naches (SOUW)	22,946	0	20,270
Stanfield (SADW)	1,600	0	1,285
Stevens (STCW)	1,950	0	1,723
Sunnyside (SNCW)	315,836	142,684	379,313
Taylor (TORW)	8,000	0	7,067
Tenant (TITW)	1,570	0	1,387
Tieton (TIEW)	75,868	38,181	94,151
Tjossem (TOEW)	4,771	0	3,831
Vertrees 1 (VETW)	2,164	0	1,738
Vertrees 2 (VESW)	704	0	565
Wapatox Power (WOPW)	20,230	0	16,929
Wapatox Irrigation (WOIW)	0	0	17,871
Westside (WESW)	31,128	8,200	29,745
Woldale (WOLW)	12,973	0	10,417
Younger (YOUW)	3,010	0	2,417
Union Gap (UNGW)	20,697	4,588	21,989

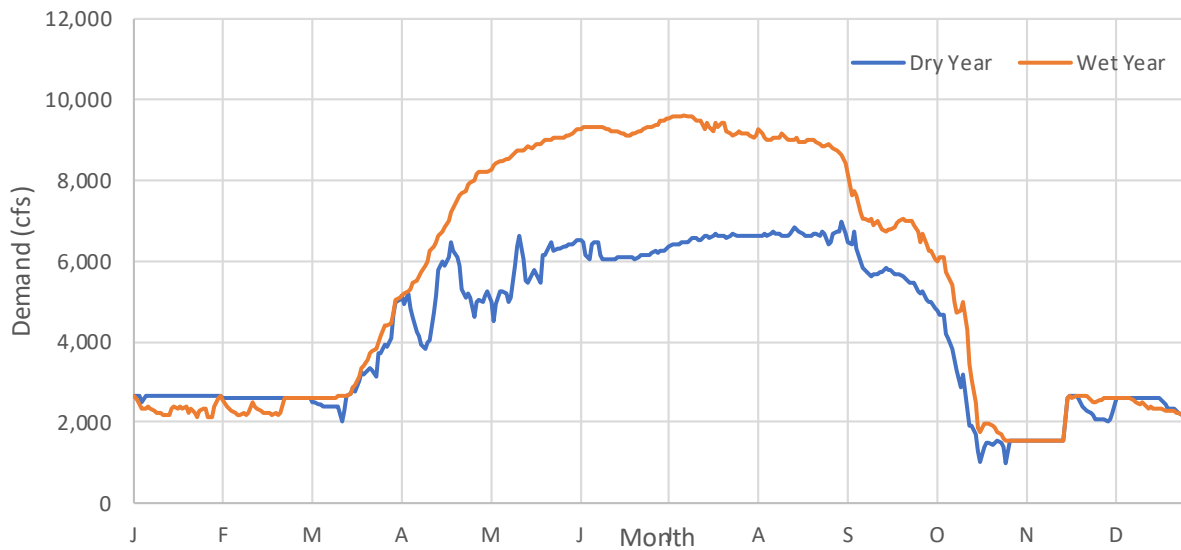


Figure 5: An example annual irrigation demand diversion for the sum of all the water users for the Yakima basin in a representative dry (2015) and wet year (2012).

When water is applied to irrigated lands, excess water can seep below the root zone and travel, via the aquifer, back to the river. The time it takes for irrigation water to return to the river channel is described by a time-dependent function known as a groundwater response function. Response functions are also used to describe the lagged effect on the river due to pumping water from the aquifer. The response functions for the Yakima model were calculated using a groundwater model of the basin (HDR 2017).

For the Modified Flows analysis, the model was corrected for groundwater responses based on 2020 level demands. In the Yakima basin, it can take up to 20 years for the system to equilibrate with respect to groundwater responses based on simulated response functions. Thus, it was necessary to calculate equilibrium groundwater response hydrographs and input them directly into the Modified Flows RiverWare model. In other words, the equilibrium groundwater return flows were calculated separately and “hardwired” into the model.

### 3.3. Yakima River Operation

Baseline operating rules for the Yakima RiverWare model reflect the operating criteria in the 2010 Modified Flows Documentation (Reclamation 2010) and the Yakima Basin Operating Plan (Reclamation 2002). Generally, each reservoir follows specific logic to make releases for flood control, irrigation, and instream flow requirements. The total demand in the system is supplied through a combination of stored water releases, unregulated flow (natural flow), and return flow. In dry years, water supply to prorated irrigation water users is reduced and streamflow targets are reduced; the reduction represents a shortage in this system. Model operations make use of a monthly forecasting process to provide an advanced indication of water availability.

### 3.4. 2020 Modified Flows in the Yakima

The 2020 Modified Flows in the Yakima basin have been calculated at a daily timestep. Figure 6 shows the time series of the daily regulated flows for the Yakima River at the mouth (blue dashed). Monthly average flows were calculated from the daily time series and are also shown on the figure (orange solid line). The plots show how much the variability was smoothed by the averaging process.

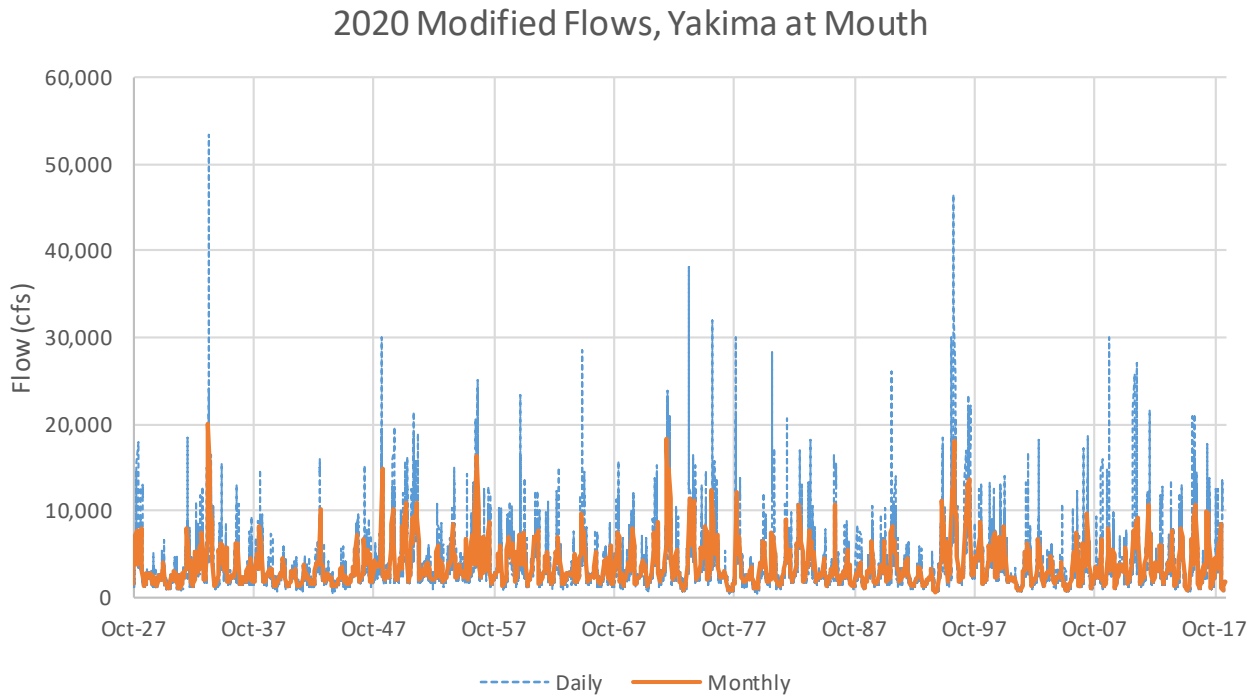


Figure 6. 2020 Modified Flows data set for water years 1926 through 2018

## 4. Discussion

Because there is no gage for the Yakima River at the mouth, historical data from the gage upstream, Yakima River at Kiona (KIOW), was compared to modeled data for that location. Table 3 shows the comparison of the modeled KIOW data to historical data for 2009 through 2018. The annual volumes for the modeled dataset were four percent larger than the actual flows on average. The maximum monthly volumes for the modeled inflows were four percent larger than the actual flows and the minimum monthly volumes were seven percent larger.

Table 3: Comparison of the modeled KIOW flows to gaged KIOW flows for water years 2009-2018. All volumes are in acre-feet.

Year	Annual Volume		Maximum Monthly Volume		Minimum Monthly Volume	
	Modeled	Actual	Modeled	Actual	Modeled	Actual
2009	2,749,241	2,638,230	476,226	441,862	72,580	61,063
2010	2,326,463	2,147,198	341,201	326,618	105,193	101,132
2011	3,637,418	3,524,124	563,821	576,587	96,872	81,940
2012	3,270,998	3,164,278	627,503	607,545	112,567	106,540
2013	2,588,239	2,506,271	375,960	421,333	108,047	105,803
2014	2,665,077	2,559,836	467,361	398,924	83,862	91,637
2015	2,445,153	2,251,271	476,607	384,133	56,148	39,299
2016	3,538,228	3,217,882	635,981	570,578	77,880	70,094
2017	3,169,599	3,242,685	593,133	619,002	73,890	74,535
2018	2,664,691	2,661,718	524,734	546,599	58,357	57,370
Averages	2,905,511	2,791,349	508,253	489,318	84,540	78,941
% Difference, Modeled vs. Actual	4%	--	4%	--	7%	--

The comparison of the daily modeled data set to the actual inflows is shown in Figure 7 for the most recent 10-year period, water years 2009 through 2018. The KIOW data accurately represent the 2009 through 2018 water years with r-squared values of 0.88 for the daily data.

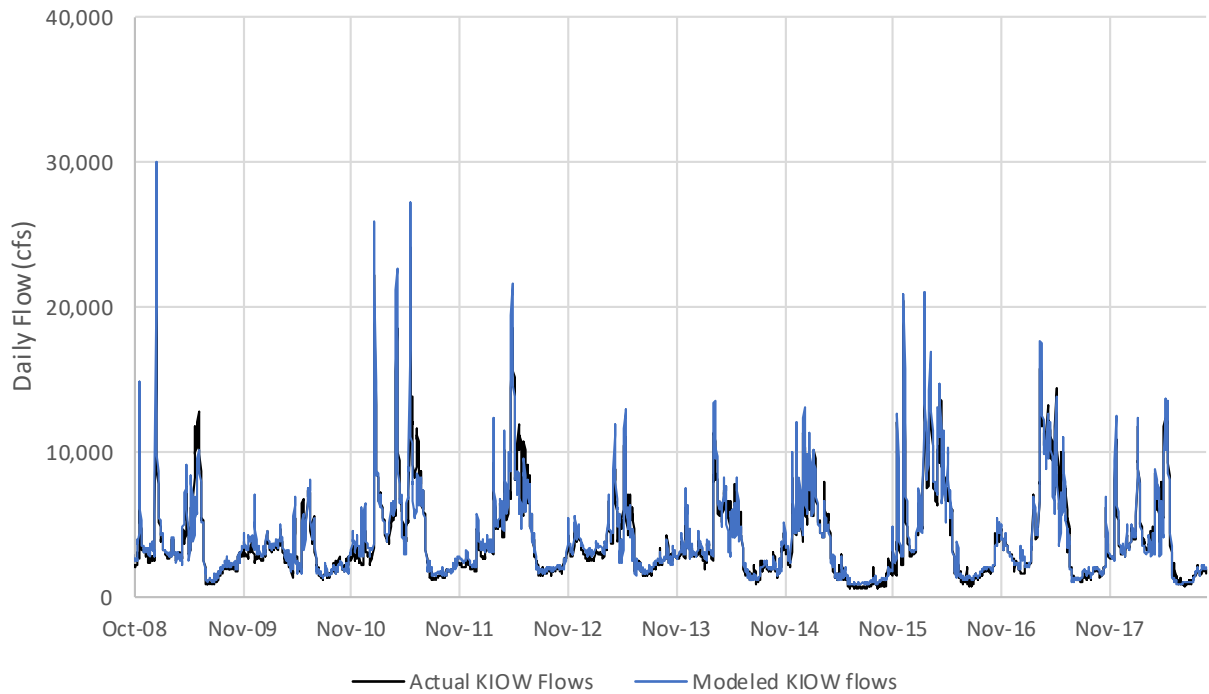


Figure 7. Modeled KIOW flows compared with the gaged KIOW flows for water years 2009 through 2018

The Modified Flows that were calculated in the 2020 level development update are similar to the 2010 level Modified Flows (Reclamation 2010; BPA 2011) data set. The small differences are largely due to using an updated RiverWare model. In addition, the 2010 Modified Flows were reported as the flows of the Yakima River at the mouth, which has no gage. In order to represent the flows as they were in the previous version of Modified Flows, the flows of the Yakima River at the mouth are represented as the KIOW gage with any downstream diversions subtracted and return flows added. The differences in annual volume and peaks for water years 1999 through 2008 (the last ten years of overlap in the two datasets) are presented in Table 4. The annual volumes for the 2020 dataset were six percent larger than the 2010 dataset on average. The maximum monthly volumes for 2020 were two percent larger than the 2010 dataset average and the minimum monthly volumes were 18 percent larger.



Table 4. Comparison of the 2020 Modified Flows dataset to the 2010 Modified Flows dataset for water years 1999 through 2008 (the last 10 years of overlap). All volumes are in acre-feet.

Year	Annual Volume		Maximum Monthly Volume		Minimum Monthly Volume	
	2020	2010	2020	2010	2020	2010
1999	3,261,378	3,112,502	444,970	506,269	129,244	115,783
2000	2,936,939	2,678,606	489,687	454,584	111,184	86,945
2001	1,140,601	1,061,530	141,452	139,210	45,284	40,951
2002	2,410,288	2,279,682	368,120	416,833	75,885	72,249
2003	2,235,531	2,143,086	370,989	373,937	85,992	56,754
2004	2,002,668	1,799,564	300,653	288,689	91,388	72,834
2005	1,404,096	1,308,134	246,410	216,132	53,049	46,362
2006	2,463,148	2,302,393	464,130	425,439	80,402	62,472
2007	2,846,867	2,705,512	597,308	563,481	69,255	55,217
2008	1,987,671	1,918,110	412,174	380,983	85,906	70,281
Averages	2,268,919	2,130,912	383,589	376,556	82,759	67,985
% Difference vs. 2010	6%	--	2%	--	18%	--

A comparison of the monthly average 2020 Modified Flows data set to the 2010 Modified Flows data set is shown in Figure 8. The data are shown for recent years of overlap, water years 1999 through 2008.

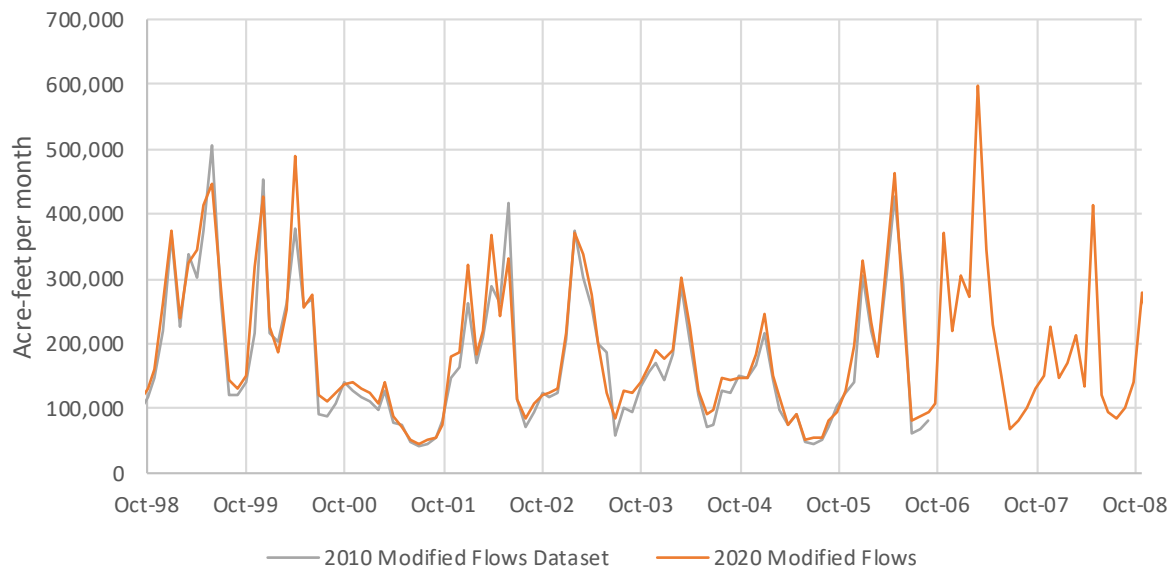


Figure 8. Monthly average 2020 Modified Flows data set compared with the 2010 Modified Flows data set of the Yakima River at the mouth for water years 1999 through 2008

## 5. Summary

The 2020 level Modified Flows for the Yakima River basin represent operations, diversions, and return flows reflective of 2008 through 2018 conditions. These current level conditions were applied to unregulated streamflow from 1928 through 2018 at a daily timestep using a RiverWare model of the basin. Flows reported at the mouth of the river are within four percent of annual volume of measured flows between 2008 and 2018.

The 2020 level Modified Flows differ from the 2010 level Modified Flows for the Yakima River basin, largely due to improvements in the RiverWare model and the representation of diversions and return flows. The difference is within six percent of the total annual volume when comparing the years 1998 through 2008.

## 6. Literature Cited

Parenthetical Reference	Bibliographic Citation
BPA 2011	Bonneville Power Administration (BPA). 2011. <i>2010 Level Modified Streamflow</i> . Cooperating agencies: U.S. Army Corps of Engineers and Bureau of Reclamation. DOE/BIP-4352. August 2011.
HDR 2017	HDR Engineering. 2017. <i>Yakima River Basin Integrated Water Resource Management Plan: Technical Memorandum Hydrologic Modeling of System Improvements Phase 3 Report</i> . January 2017.
Reclamation 2002	Bureau of Reclamation. 2002. <i>Interim Comprehensive Basin Operating Plan for the Yakima Project, Washington</i> . November 2002.
Reclamation 2010	Bureau of Reclamation. 2010. <i>Naturalized and Modified Flows of the Yakima River Basin, Columbia River Tributary, Washington</i> . March 2010.
Reclamation 2017	Bureau of Reclamation. 2017. <i>Unregulated Flows in the Upper Deschutes Basin, Oregon</i> . October 2017.

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# Appendix A: Unregulated Flows Calculations

Table A-1. Locations of unregulated flow calculations and equation to convert gain/loss into unregulated flows.

Site Name	Reclamation Gage Name	Flow Calculation
Keechelus Reservoir	KEE	$KEE_{unreg} = KEE_{gain/loss}$
Kachess Reservoir	KAC	$KAC_{unreg} = KAC_{gain/loss}$
Yakima River at Easton, WA	EASW	$EASW_{unreg} = KEE_{gain/loss} + KAC_{gain/loss} + EASW_{gain/loss}$
Cle Elum Reservoir	CLE	$CLE_{unreg} = CLE_{gain/loss}$
Yakima River at Cle Elum, WA	YUMW	$YUMW_{unreg} = KEE_{gain/loss} + KAC_{gain/loss} + EASW_{gain/loss} + CLE_{gain/loss} + YUMW_{gain/loss}$
Yakima River near Umtanum, WA	UMTW	$UMTW_{unreg} = KEE_{gain/loss} + KAC_{gain/loss} + EASW_{gain/loss} + CLE_{gain/loss} + YUMW_{gain/loss} + UMTW_{gain/loss}$
Bumping Reservoir	BUM	$BUM_{unreg} = BUM_{gain/loss}$
American River near Nile, WA	AMRW	$AMRW_{unreg} = AMRW_{gain/loss}$
Naches River near Cliffdell, WA	CLFW	$CLFW_{unreg} = BUM_{gain/loss} + AMRW_{gain/loss} + CLFW_{gain/loss}$
Rimrock Reservoir	RIM	$RIM_{unreg} = RIM_{gain/loss}$
Naches River near Naches, WA	NACW	$NACW_{unreg} = BUM_{gain/loss} + AMRW_{gain/loss} + CLFW_{gain/loss} + RIM_{gain/loss} + NACW_{gain/loss}$
Ahtanum Creek near Union Gap, WA	AUGW	$AUGW_{unreg} = AUGW_{gain/loss}$
Yakima River near Parker, WA	PARW	$PARW_{unreg} = KEE_{gain/loss} + KAC_{gain/loss} + EASW_{gain/loss} + CLE_{gain/loss} + YUMW_{gain/loss} + UMTW_{gain/loss} + BUM_{gain/loss} + AMRW_{gain/loss} + CLFW_{gain/loss} + RIM_{gain/loss} + NACW_{gain/loss} + AUGW_{gain/loss} + PARW_{gain/loss}$
Yakima River at Euclid Rd. bridge near Grandview, WA	YGVW	$YGVW_{unreg} = KEE_{gain/loss} + KAC_{gain/loss} + EASW_{gain/loss} + CLE_{gain/loss} + YUMW_{gain/loss} + UMTW_{gain/loss} + BUM_{gain/loss} + AMRW_{gain/loss} + CLFW_{gain/loss} + RIM_{gain/loss} + NACW_{gain/loss} + AUGW_{gain/loss} + PARW_{gain/loss} + YGVW_{gain/loss}$
Yakima River near Prosser, WA	YRPW	$YRPW_{unreg} = KEE_{gain/loss} + KAC_{gain/loss} + EASW_{gain/loss} + CLE_{gain/loss} + YUMW_{gain/loss} + UMTW_{gain/loss} + BUM_{gain/loss} + AMRW_{gain/loss} + CLFW_{gain/loss} + RIM_{gain/loss} + NACW_{gain/loss} + AUGW_{gain/loss} + PARW_{gain/loss} + YGVW_{gain/loss} + YRPW_{gain/loss}$
Yakima River at Kiona, WA	KIOW	$KIOW_{unreg} = KEE_{gain/loss} + KAC_{gain/loss} + EASW_{gain/loss} + CLE_{gain/loss} + YUMW_{gain/loss} + UMTW_{gain/loss} + BUM_{gain/loss} + AMRW_{gain/loss} + CLFW_{gain/loss} + RIM_{gain/loss} + NACW_{gain/loss} + AUGW_{gain/loss} +$

Site Name	Reclamation Gage Name	Flow Calculation
		$PARW_{gain/loss} + YGVW_{gain/loss} + YRPW_{gain/loss} + KIW_{gain/loss}$
Yakima at mouth		$Yakima\ at\ mouth_{unreg} = KEE_{gain/loss} + KAC_{gain/loss} + EASW_{gain/loss} + CLE_{gain/loss} + YUMW_{gain/loss} + UMTW_{gain/loss} + BUM_{gain/loss} + AMRW_{gain/loss} + CLFW_{gain/loss} + RIM_{gain/loss} + NACW_{gain/loss} + AUGW_{gain/loss} + PARW_{gain/loss} + YGVW_{gain/loss} + YRPW_{gain/loss} + KIW_{gain/loss} + Yakima\ at\ mouth_{gain/loss}$

# Appendix B: Unregulated Flows Data

Table B-1. Unregulated flows of the Yakima River at the mouth for water years 1926 through 2018 (acre-feet per month)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1926	122,833	110,344	300,584	219,661	206,349	394,685	481,575	348,332	214,380	144,754	133,105	97,123
1927	194,590	185,137	320,359	190,610	180,646	279,453	521,926	822,940	978,143	383,642	236,026	246,364
1928	332,390	422,491	424,133	477,276	201,977	413,726	473,985	978,598	493,680	293,809	199,389	140,142
1929	181,650	131,251	110,337	98,824	95,987	209,117	266,389	693,137	570,714	312,009	164,772	131,160
1930	107,675	89,318	106,379	96,886	250,753	282,216	616,253	431,587	330,244	174,891	130,693	100,413
1931	120,364	127,801	90,760	132,041	198,310	260,107	367,563	655,695	342,956	144,591	93,341	92,744
1932	117,479	194,076	126,904	215,788	282,038	651,014	635,361	811,340	710,284	318,212	143,822	124,989
1933	152,452	493,755	355,305	316,604	111,889	186,649	532,778	765,393	1,031,278	611,660	235,321	221,515
1934	344,168	298,426	1,104,887	708,330	408,514	664,303	747,912	554,092	272,715	164,769	134,817	144,125
1935	212,257	414,101	257,894	442,249	342,007	276,411	368,085	752,548	738,190	294,155	159,377	158,792
1936	112,442	67,238	66,455	115,287	71,817	247,423	709,205	1,060,472	750,564	228,672	139,746	133,516
1937	85,129	53,662	114,463	61,406	71,183	219,415	429,731	683,965	884,670	325,214	193,914	164,838
1938	112,609	290,103	311,909	299,549	155,216	396,847	789,744	956,654	723,249	235,907	150,556	129,137
1939	131,086	123,045	185,044	216,908	110,953	247,446	488,045	550,873	371,284	219,926	139,089	128,111
1940	118,701	100,595	218,996	105,778	207,556	387,621	514,304	569,778	301,409	171,334	129,822	145,404
1941	125,241	104,293	182,162	118,280	120,611	288,207	421,315	350,358	236,518	128,520	121,917	176,092
1942	178,943	185,863	285,368	111,353	132,284	192,177	457,250	528,214	429,605	229,360	152,690	134,595
1943	104,719	197,246	262,405	242,188	200,022	302,934	933,040	728,121	772,476	456,393	207,045	141,822
1944	140,068	98,805	181,634	81,193	99,753	173,246	283,619	406,272	336,525	171,054	153,383	160,745
1945	114,483	100,794	124,911	262,721	234,565	159,473	284,540	709,970	414,543	209,912	164,167	166,621
1946	136,629	156,633	149,163	199,509	118,332	274,963	603,226	1,140,510	819,907	360,384	182,545	184,280
1947	187,247	141,269	451,409	243,043	313,484	426,409	561,536	735,223	489,502	231,721	176,565	178,892
1948	327,479	325,071	224,521	187,248	197,538	235,240	431,387	1,043,187	1,258,164	358,519	226,169	183,704
1949	178,528	148,216	143,993	60,167	157,523	398,221	820,916	1,285,703	762,585	344,765	218,145	194,481
1950	233,527	334,436	258,577	127,747	188,162	428,137	587,001	965,572	1,295,183	596,998	241,001	164,103
1951	283,352	366,336	540,440	311,060	578,683	345,445	813,771	1,102,247	732,307	270,888	176,489	181,925
1952	251,240	174,213	162,656	97,810	200,081	231,053	533,639	749,172	452,315	272,254	180,619	149,084
1953	91,908	53,666	64,406	455,460	399,323	223,582	376,079	755,775	712,339	406,947	209,088	146,159
1954	125,074	140,683	327,264	196,416	224,834	289,057	542,405	1,049,625	878,905	624,041	284,138	213,555
1955	202,148	211,926	135,975	117,457	150,689	132,719	242,919	594,631	924,653	514,830	203,192	174,953
1956	299,473	428,505	440,884	275,895	163,725	438,265	1,095,471	1,533,373	1,115,552	535,036	229,455	200,774
1957	233,793	176,561	473,259	114,310	142,426	292,104	637,521	1,020,449	440,333	176,171	161,271	148,027
1958	156,251	100,167	162,325	167,979	314,421	312,510	584,821	1,049,066	447,184	170,080	124,623	172,473
1959	201,934	454,131	520,855	468,285	251,138	339,671	619,090	711,836	733,879	303,146	163,516	315,448
1960	419,962	487,334	357,695	146,939	197,804	325,804	598,427	696,282	580,336	203,475	160,282	170,817

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1961	171,311	214,828	125,699	250,824	490,967	481,757	666,513	968,208	838,587	251,366	153,167	152,238
1962	180,975	123,686	184,450	340,335	265,789	192,298	643,475	566,543	509,010	260,936	180,008	153,635
1963	226,747	338,362	358,712	224,282	489,333	284,064	483,537	549,000	331,201	205,052	167,423	159,323
1964	137,395	152,442	133,683	184,417	140,225	173,574	340,699	628,837	1,017,704	496,217	230,640	178,751
1965	197,016	124,026	300,369	288,460	495,021	370,078	698,091	752,466	631,810	265,070	186,553	172,797
1966	161,619	127,615	111,658	124,838	85,561	242,654	578,411	712,151	490,112	294,672	137,240	162,168
1967	154,840	128,087	328,068	277,868	267,439	187,392	258,640	760,896	874,740	290,651	146,752	128,675
1968	267,017	222,198	321,414	412,323	547,120	477,059	268,031	515,979	415,689	195,256	201,933	230,988
1969	220,497	275,693	203,159	243,874	130,963	346,550	690,442	1,151,493	683,768	207,163	145,631	189,090
1970	171,575	97,716	94,837	205,591	226,931	312,209	384,046	760,066	713,680	222,018	142,652	169,320
1971	149,570	134,671	129,320	388,310	457,042	241,299	464,006	1,179,661	897,589	514,592	218,323	216,016
1972	178,079	162,152	146,074	235,517	409,330	1,030,385	632,558	1,416,936	1,239,062	542,222	279,489	249,194
1973	181,389	125,388	290,175	275,068	128,558	176,894	264,069	461,166	313,961	140,705	103,074	139,217
1974	129,313	223,542	274,775	842,117	327,793	361,268	744,649	1,013,584	1,340,007	683,924	280,797	202,544
1975	149,074	102,887	216,176	339,563	235,468	319,633	411,505	983,379	960,334	479,098	252,059	181,397
1976	201,170	298,382	771,193	461,774	281,111	232,693	557,396	969,271	614,762	435,146	321,722	219,169
1977	169,399	101,686	109,664	149,711	118,078	92,584	211,495	245,055	252,194	120,394	125,746	175,673
1978	125,842	296,885	831,346	257,552	266,634	530,434	595,620	648,040	542,683	308,510	206,393	245,598
1979	124,684	105,420	109,112	62,830	144,712	295,191	339,896	658,247	338,544	171,962	91,640	80,185
1980	64,799	75,776	356,400	166,649	216,141	449,439	753,252	800,122	412,661	242,327	168,935	188,519
1981	125,512	227,138	731,413	408,197	512,970	345,192	336,610	464,031	320,642	219,527	134,707	145,043
1982	205,747	155,154	213,709	310,777	680,061	482,113	440,340	852,726	891,058	402,563	186,723	209,496
1983	204,347	155,521	274,425	493,573	378,116	728,270	607,854	919,125	574,172	367,627	169,364	213,810
1984	146,922	296,332	184,520	632,670	297,135	431,835	453,675	600,507	755,953	371,041	183,824	204,379
1985	175,648	141,775	106,593	75,270	101,187	195,428	588,755	707,688	548,176	168,749	149,857	211,332
1986	202,214	212,720	78,485	144,859	365,507	674,797	480,386	578,468	393,951	200,400	121,501	197,179
1987	117,608	249,175	132,335	98,133	145,211	446,001	565,503	696,150	297,757	168,425	119,167	91,019
1988	67,740	51,188	151,552	107,911	184,476	282,973	602,120	627,829	463,460	218,085	121,043	119,941
1989	160,044	220,484	205,875	204,667	130,426	250,775	737,782	663,294	444,600	209,848	156,243	139,199
1990	115,823	220,507	264,271	284,662	218,037	298,988	766,391	608,624	560,405	256,320	201,401	156,203
1991	244,625	694,963	253,912	262,322	483,729	265,670	482,251	612,238	496,673	317,062	186,837	141,811
1992	96,187	166,138	241,201	198,763	274,203	397,313	432,693	404,336	199,157	134,872	101,493	134,305
1993	80,306	115,098	94,885	123,184	125,253	307,759	490,597	701,107	344,325	176,806	131,540	109,995
1994	90,873	54,220	100,328	160,333	104,498	283,317	510,651	467,410	248,806	112,390	83,288	72,833
1995	109,946	150,579	280,494	257,053	813,028	548,320	513,735	946,719	529,628	263,445	176,272	179,753
1996	265,560	794,715	570,100	584,095	1,071,304	542,901	731,883	642,084	506,418	264,412	189,813	193,179
1997	172,505	193,902	217,179	503,632	458,443	682,377	862,362	1,347,552	952,650	462,296	235,097	239,475
1998	349,990	260,494	169,556	203,234	282,244	427,137	554,778	953,700	510,793	221,115	152,331	123,317
1999	115,560	190,669	321,410	417,281	235,062	345,912	529,954	892,020	1,025,668	615,771	297,199	178,289
2000	156,829	346,869	379,184	161,059	154,532	267,578	725,900	710,885	609,439	253,410	138,620	178,690



Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2001	169,450	69,015	60,223	72,483	63,922	179,432	278,875	457,712	254,959	122,335	119,148	93,711
2002	108,329	239,167	193,466	357,057	202,275	270,570	658,338	773,606	801,481	317,040	135,096	132,468
2003	106,958	64,748	90,825	321,390	415,494	454,506	528,769	620,990	465,979	166,402	153,088	134,282
2004	191,026	222,527	161,655	156,499	184,709	398,519	526,784	525,670	345,790	173,678	219,058	243,825
2005	175,521	183,556	245,016	351,092	153,378	138,047	262,604	352,864	176,669	106,224	90,166	120,461
2006	122,142	137,128	178,145	397,484	238,438	207,984	603,681	1,002,016	691,981	216,008	134,908	125,286
2007	77,939	468,564	204,731	311,707	301,307	750,153	562,781	690,505	434,227	193,856	139,429	135,134
2008	169,472	104,747	242,696	106,610	146,101	230,791	307,723	1,026,116	662,251	306,383	177,068	142,967
2009	139,200	322,325	159,705	478,975	141,482	205,174	501,389	892,502	606,937	189,498	159,976	177,534
2010	189,423	217,230	157,456	209,206	191,210	257,799	393,374	648,049	777,845	303,911	168,200	227,806
2011	145,958	207,349	203,627	623,104	339,502	369,413	607,725	964,496	875,283	491,990	205,341	166,720
2012	177,628	105,772	121,704	197,503	279,143	347,324	826,961	988,342	798,768	450,517	185,404	146,827
2013	207,964	256,518	228,862	141,553	155,074	338,439	648,786	827,977	494,619	228,267	197,233	245,816
2014	235,787	184,243	217,201	204,198	161,880	592,579	604,580	846,489	478,397	239,766	199,227	171,562
2015	202,443	357,050	411,562	526,045	493,274	378,031	281,324	286,979	123,703	79,091	91,638	102,572
2016	59,577	384,837	446,237	231,840	629,289	636,528	854,107	641,492	302,262	159,865	123,884	122,667
2017	228,551	237,011	133,146	35,451	222,248	698,618	817,361	1,055,432	562,792	163,576	120,219	128,957
2018	181,179	307,652	190,792	244,426	414,049	228,199	591,894	870,714	226,350	14,695	68,054	111,447

Table B-2. Unregulated flows of the Yakima River at the mouth for water years 1926 through 2018 (cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1926	1,998	1,854	4,888	3,572	3,715	6,419	8,093	5,665	3,603	2,354	2,165	1,632
1927	3,165	3,111	5,210	3,100	3,253	4,545	8,771	13,384	16,438	6,239	3,839	4,140
1928	5,406	7,100	6,898	7,762	3,511	6,729	7,965	15,915	8,296	4,778	3,243	2,355
1929	2,954	2,206	1,794	1,607	1,728	3,401	4,477	11,273	9,591	5,074	2,680	2,204
1930	1,751	1,501	1,730	1,576	4,515	4,590	10,356	7,019	5,550	2,844	2,125	1,687
1931	1,958	2,148	1,476	2,147	3,571	4,230	6,177	10,664	5,763	2,352	1,518	1,559
1932	1,911	3,262	2,064	3,509	4,903	10,588	10,677	13,195	11,937	5,175	2,339	2,100
1933	2,479	8,298	5,778	5,149	2,015	3,036	8,953	12,448	17,331	9,948	3,827	3,723
1934	5,597	5,015	17,969	11,520	7,356	10,804	12,569	9,011	4,583	2,680	2,193	2,422
1935	3,452	6,959	4,194	7,192	6,158	4,495	6,186	12,239	12,406	4,784	2,592	2,669
1936	1,829	1,130	1,081	1,875	1,249	4,024	11,918	17,247	12,613	3,719	2,273	2,244
1937	1,384	902	1,862	999	1,282	3,568	7,222	11,123	14,867	5,289	3,154	2,770
1938	1,831	4,875	5,073	4,872	2,795	6,454	13,272	15,558	12,154	3,837	2,449	2,170
1939	2,132	2,068	3,009	3,528	1,998	4,024	8,202	8,959	6,240	3,577	2,262	2,153
1940	1,930	1,691	3,562	1,720	3,608	6,304	8,643	9,266	5,065	2,786	2,111	2,444
1941	2,037	1,753	2,963	1,924	2,172	4,687	7,080	5,698	3,975	2,090	1,983	2,959
1942	2,910	3,123	4,641	1,811	2,382	3,125	7,684	8,590	7,220	3,730	2,483	2,262
1943	1,703	3,315	4,268	3,939	3,602	4,927	15,680	11,842	12,982	7,422	3,367	2,383

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1944	2,278	1,660	2,954	1,320	1,734	2,818	4,766	6,607	5,655	2,782	2,495	2,701
1945	1,862	1,694	2,031	4,273	4,224	2,594	4,782	11,546	6,967	3,414	2,670	2,800
1946	2,222	2,632	2,426	3,245	2,131	4,472	10,137	18,548	13,779	5,861	2,969	3,097
1947	3,045	2,374	7,341	3,953	5,645	6,935	9,437	11,957	8,226	3,769	2,872	3,006
1948	5,326	5,463	3,651	3,045	3,434	3,826	7,250	16,966	21,144	5,831	3,678	3,087
1949	2,903	2,491	2,342	979	2,836	6,476	13,796	20,910	12,815	5,607	3,548	3,268
1950	3,798	5,620	4,205	2,078	3,388	6,963	9,865	15,703	21,766	9,709	3,919	2,758
1951	4,608	6,156	8,789	5,059	10,420	5,618	13,676	17,926	12,307	4,406	2,870	3,057
1952	4,086	2,928	2,645	1,591	3,478	3,758	8,968	12,184	7,601	4,428	2,937	2,505
1953	1,495	902	1,047	7,407	7,190	3,636	6,320	12,291	11,971	6,618	3,400	2,456
1954	2,034	2,364	5,322	3,194	4,048	4,701	9,115	17,070	14,770	10,149	4,621	3,589
1955	3,288	3,561	2,211	1,910	2,713	2,158	4,082	9,671	15,539	8,373	3,305	2,940
1956	4,870	7,201	7,170	4,487	2,846	7,128	18,410	24,938	18,747	8,701	3,732	3,374
1957	3,802	2,967	7,697	1,859	2,564	4,751	10,714	16,596	7,400	2,865	2,623	2,488
1958	2,541	1,683	2,640	2,732	5,661	5,082	9,828	17,061	7,515	2,766	2,027	2,898
1959	3,284	7,632	8,471	7,616	4,522	5,524	10,404	11,577	12,333	4,930	2,659	5,301
1960	6,830	8,190	5,817	2,390	3,439	5,299	10,057	11,324	9,753	3,309	2,607	2,871
1961	2,786	3,610	2,044	4,079	8,840	7,835	11,201	15,746	14,093	4,088	2,491	2,558
1962	2,943	2,079	3,000	5,535	4,786	3,127	10,814	9,214	8,554	4,244	2,927	2,582
1963	3,688	5,686	5,834	3,648	8,811	4,620	8,126	8,929	5,566	3,335	2,723	2,677
1964	2,234	2,562	2,174	2,999	2,438	2,823	5,726	10,227	17,103	8,070	3,751	3,004
1965	3,204	2,084	4,885	4,691	8,913	6,019	11,732	12,238	10,618	4,311	3,034	2,904
1966	2,628	2,145	1,816	2,030	1,541	3,946	9,720	11,582	8,236	4,792	2,232	2,725
1967	2,518	2,153	5,335	4,519	4,815	3,048	4,347	12,375	14,700	4,727	2,387	2,162
1968	4,343	3,734	5,227	6,706	9,512	7,759	4,504	8,391	6,986	3,175	3,284	3,882
1969	3,586	4,633	3,304	3,966	2,358	5,636	11,603	18,727	11,491	3,369	2,368	3,178
1970	2,790	1,642	1,542	3,344	4,086	5,078	6,454	12,361	11,994	3,611	2,320	2,845
1971	2,432	2,263	2,103	6,315	8,229	3,924	7,798	19,185	15,084	8,369	3,551	3,630
1972	2,896	2,725	2,376	3,830	7,116	16,757	10,630	23,044	20,823	8,818	4,545	4,188
1973	2,950	2,107	4,719	4,473	2,315	2,877	4,438	7,500	5,276	2,288	1,676	2,340
1974	2,103	3,757	4,469	13,696	5,902	5,875	12,514	16,484	22,519	11,123	4,567	3,404
1975	2,424	1,729	3,516	5,522	4,240	5,198	6,915	15,993	16,139	7,792	4,099	3,048
1976	3,272	5,014	12,542	7,510	4,887	3,784	9,367	15,763	10,331	7,077	5,232	3,683
1977	2,755	1,709	1,783	2,435	2,126	1,506	3,554	3,985	4,238	1,958	2,045	2,952
1978	2,047	4,989	13,520	4,189	4,801	8,627	10,010	10,539	9,120	5,017	3,357	4,127
1979	2,028	1,772	1,775	1,022	2,606	4,801	5,712	10,705	5,689	2,797	1,490	1,348
1980	1,054	1,273	5,796	2,710	3,758	7,309	12,659	13,013	6,935	3,941	2,747	3,168
1981	2,041	3,817	11,895	6,639	9,236	5,614	5,657	7,547	5,388	3,570	2,191	2,437
1982	3,346	2,607	3,476	5,054	12,245	7,841	7,400	13,868	14,975	6,547	3,037	3,521
1983	3,323	2,614	4,463	8,027	6,808	11,844	10,215	14,948	9,649	5,979	2,754	3,593

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1984	2,389	4,980	3,001	10,289	5,166	7,023	7,624	9,766	12,704	6,034	2,990	3,435
1985	2,857	2,383	1,734	1,224	1,822	3,178	9,894	11,509	9,212	2,744	2,437	3,551
1986	3,289	3,575	1,276	2,356	6,581	10,974	8,073	9,408	6,620	3,259	1,976	3,314
1987	1,913	4,187	2,152	1,596	2,615	7,253	9,503	11,322	5,004	2,739	1,938	1,530
1988	1,102	860	2,465	1,755	3,207	4,602	10,119	10,211	7,789	3,547	1,969	2,016
1989	2,603	3,705	3,348	3,329	2,348	4,078	12,399	10,787	7,472	3,413	2,541	2,339
1990	1,884	3,706	4,298	4,630	3,926	4,862	12,879	9,898	9,418	4,169	3,275	2,625
1991	3,978	11,679	4,129	4,266	8,710	4,321	8,104	9,957	8,347	5,156	3,039	2,383
1992	1,564	2,792	3,923	3,233	4,767	6,462	7,272	6,576	3,347	2,193	1,651	2,257
1993	1,306	1,934	1,543	2,003	2,255	5,005	8,245	11,402	5,786	2,875	2,139	1,849
1994	1,478	911	1,632	2,608	1,882	4,608	8,582	7,602	4,181	1,828	1,355	1,224
1995	1,788	2,531	4,562	4,181	14,639	8,917	8,633	15,397	8,901	4,284	2,867	3,021
1996	4,319	13,355	9,272	9,499	18,624	8,829	12,300	10,442	8,511	4,300	3,087	3,246
1997	2,805	3,259	3,532	8,191	8,255	11,098	14,492	21,916	16,010	7,518	3,823	4,024
1998	5,692	4,378	2,758	3,305	5,082	6,947	9,323	15,510	8,584	3,596	2,477	2,072
1999	1,879	3,204	5,227	6,786	4,232	5,626	8,906	14,507	17,237	10,014	4,833	2,996
2000	2,551	5,829	6,167	2,619	2,687	4,352	12,199	11,561	10,242	4,121	2,254	3,003
2001	2,756	1,160	979	1,179	1,151	2,918	4,687	7,444	4,285	1,990	1,938	1,575
2002	1,762	4,019	3,146	5,807	3,642	4,400	11,064	12,581	13,469	5,156	2,197	2,226
2003	1,739	1,088	1,477	5,227	7,481	7,392	8,886	10,099	7,831	2,706	2,490	2,257
2004	3,107	3,740	2,629	2,545	3,211	6,481	8,853	8,549	5,811	2,825	3,563	4,098
2005	2,855	3,085	3,985	5,710	2,762	2,245	4,413	5,739	2,969	1,728	1,466	2,024
2006	1,986	2,304	2,897	6,464	4,293	3,382	10,145	16,296	11,629	3,513	2,194	2,105
2007	1,268	7,874	3,330	5,069	5,425	12,200	9,458	11,230	7,297	3,153	2,268	2,271
2008	2,756	1,760	3,947	1,734	2,540	3,753	5,171	16,688	11,129	4,983	2,880	2,403
2009	2,264	5,417	2,597	7,790	2,547	3,337	8,426	14,515	10,200	3,082	2,602	2,984
2010	3,081	3,651	2,561	3,402	3,443	4,193	6,611	10,539	13,072	4,943	2,735	3,828
2011	2,374	3,485	3,312	10,134	6,113	6,008	10,213	15,686	14,709	8,001	3,339	2,802
2012	2,889	1,778	1,979	3,212	4,853	5,649	13,897	16,074	13,424	7,327	3,015	2,467
2013	3,382	4,311	3,722	2,302	2,792	5,504	10,903	13,466	8,312	3,712	3,208	4,131
2014	3,835	3,096	3,532	3,321	2,915	9,637	10,160	13,767	8,040	3,899	3,240	2,883
2015	3,292	6,000	6,693	8,555	8,882	6,148	4,728	4,667	2,079	1,286	1,490	1,724
2016	969	6,467	7,257	3,770	10,940	10,352	14,354	10,433	5,080	2,600	2,015	2,061
2017	3,717	3,983	2,165	577	4,002	11,362	13,736	17,165	9,458	2,660	1,955	2,167
2018	2,947	5,170	3,103	3,975	7,455	3,711	9,947	14,161	3,804	239	1,107	1,873

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# Appendix C: Modified Flows Data

Table C-1. Modified flows of the Yakima River at the mouth for water years 1926 through 2018 (acre-feet per month)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1926	126,897	147,025	216,469	203,611	188,245	280,849	177,865	94,409	78,260	68,107	64,385	68,955
1927	125,585	164,650	270,929	192,096	178,200	243,566	292,312	356,097	363,642	129,609	104,107	100,230
1928	183,965	390,966	439,216	463,401	214,547	323,284	280,925	484,431	183,628	111,562	93,016	102,446
1929	141,685	166,165	152,809	144,751	132,430	172,603	104,923	170,050	139,026	100,181	89,831	84,505
1930	125,497	145,778	133,265	126,797	181,789	185,661	238,797	100,183	103,482	83,315	76,974	72,309
1931	102,536	144,974	127,656	123,922	170,612	172,889	110,760	165,519	106,922	78,444	71,694	70,085
1932	94,091	165,982	146,051	187,802	182,037	482,736	314,669	270,406	254,813	123,071	93,388	100,007
1933	132,370	311,661	292,177	282,652	158,356	198,450	345,950	377,836	443,639	293,874	127,310	130,110
1934	181,999	377,730	1,200,668	879,656	419,183	651,709	503,209	267,584	100,922	91,764	99,973	105,700
1935	155,618	319,063	248,603	370,755	331,282	245,362	185,882	228,364	348,108	125,384	111,617	120,394
1936	128,208	151,244	135,469	147,364	127,925	208,935	372,727	382,767	348,440	106,931	99,935	107,296
1937	115,758	131,056	135,856	118,917	101,194	184,165	208,540	170,847	266,030	128,962	121,805	134,155
1938	118,830	200,976	279,384	301,806	185,206	359,186	480,098	395,793	354,276	127,285	119,041	113,130
1939	122,272	153,632	174,283	196,171	136,738	197,503	165,628	116,441	113,514	91,090	93,406	96,807
1940	108,812	126,116	163,531	145,232	183,512	280,299	205,310	154,894	101,152	90,869	96,697	101,899
1941	112,749	135,248	179,101	150,569	144,469	197,170	152,234	88,418	95,315	85,181	88,352	95,841
1942	100,692	149,475	222,853	140,474	150,993	164,248	146,968	139,591	123,123	100,400	96,932	97,524
1943	106,898	170,576	241,463	235,871	199,744	238,036	600,088	252,240	218,789	209,067	128,494	112,801
1944	139,127	154,986	172,119	132,147	122,543	139,115	81,654	86,134	104,451	93,449	95,450	93,921
1945	102,381	126,769	132,753	192,973	189,431	136,956	107,744	161,791	142,715	98,230	114,033	104,641
1946	109,485	144,962	152,943	206,732	139,826	236,660	317,787	440,302	316,350	137,099	121,266	139,947
1947	149,900	165,298	400,772	232,345	266,369	333,734	269,594	313,628	215,064	117,466	121,096	129,550
1948	201,591	253,249	234,588	213,969	200,746	214,749	263,392	440,759	866,668	162,246	140,696	132,981
1949	155,489	173,763	173,404	143,523	171,973	350,702	497,719	614,010	401,104	129,683	139,223	135,745
1950	160,741	232,324	267,192	193,064	190,198	488,500	471,582	541,735	638,985	318,995	129,262	115,737
1951	170,329	315,442	551,825	381,375	511,142	463,933	637,259	568,337	382,994	130,508	128,312	141,994
1952	177,240	182,135	196,413	147,786	208,889	210,116	245,014	212,943	144,715	127,640	129,301	131,021
1953	125,932	134,593	138,500	311,956	325,280	201,991	142,763	268,240	234,881	122,643	129,732	127,987
1954	139,754	156,911	249,692	208,497	226,716	270,440	321,592	523,203	313,554	292,269	147,256	146,218
1955	171,687	215,774	199,075	166,744	164,048	140,101	159,786	205,025	395,780	193,486	129,814	137,986
1956	180,112	330,669	439,006	333,815	212,240	587,842	894,173	984,590	597,560	243,598	155,133	165,426
1957	176,957	189,364	419,527	185,105	164,302	264,493	406,040	533,269	183,243	101,810	114,317	127,821
1958	164,663	154,247	171,685	181,309	266,360	278,951	323,838	364,381	130,030	92,522	101,848	122,954
1959	128,100	318,326	398,635	413,003	264,052	313,936	369,165	251,751	310,787	116,340	115,294	158,312
1960	216,930	393,758	439,104	240,722	214,056	296,634	440,257	226,202	231,508	86,801	114,208	132,602

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1961	143,845	191,988	185,615	220,155	383,406	395,769	432,897	414,929	458,010	97,263	113,575	114,452
1962	143,531	159,922	184,967	288,052	248,719	190,153	310,807	174,784	136,718	105,663	106,237	118,965
1963	165,013	273,628	319,510	236,400	382,538	242,950	262,332	182,237	103,047	107,521	109,944	118,298
1964	122,329	156,420	168,425	172,749	159,727	155,899	150,187	161,482	302,121	117,941	124,654	120,738
1965	142,815	157,747	272,278	298,408	528,007	373,313	450,539	294,330	280,757	116,935	122,196	131,112
1966	142,476	153,096	157,549	161,264	127,426	207,923	308,052	188,150	127,295	118,686	98,255	117,488
1967	127,680	154,138	258,791	227,074	241,284	171,596	121,710	265,911	362,894	127,310	99,667	100,935
1968	143,001	202,607	240,316	336,246	417,393	424,268	119,758	158,262	177,554	91,958	123,362	141,258
1969	150,191	225,796	220,669	238,324	167,062	314,114	445,653	489,211	355,195	105,779	109,990	123,034
1970	138,742	140,612	152,302	214,162	234,173	258,276	185,263	215,090	234,926	83,367	98,088	117,125
1971	133,364	151,645	175,511	318,863	401,279	237,910	290,795	535,675	366,723	172,917	114,513	160,798
1972	156,570	170,727	183,668	246,545	332,587	1,097,505	577,073	899,604	668,942	259,455	136,627	142,315
1973	156,517	158,505	287,730	331,681	167,237	171,177	108,668	107,242	89,683	62,116	72,672	84,694
1974	118,142	224,562	295,932	693,039	338,317	362,581	521,886	520,323	664,405	348,161	134,664	141,278
1975	153,023	149,774	226,741	344,052	247,003	341,672	294,122	498,990	440,769	220,408	139,320	142,771
1976	156,202	224,184	745,758	525,729	290,993	300,573	416,969	441,566	213,883	161,377	148,110	145,081
1977	158,239	143,052	153,046	188,063	127,589	105,282	61,885	63,781	59,090	59,783	66,375	98,192
1978	103,401	179,700	727,802	296,694	271,786	414,614	388,595	222,913	149,211	131,854	113,620	125,335
1979	119,770	142,764	155,892	130,788	165,537	218,427	143,216	123,158	78,139	69,624	70,247	68,579
1980	76,193	132,663	235,854	196,992	197,962	395,981	377,377	310,993	148,361	124,627	115,301	129,868
1981	123,409	175,927	451,865	416,038	380,523	289,484	121,469	117,428	106,190	95,090	84,853	102,144
1982	137,404	156,632	202,714	255,874	490,466	421,250	258,345	294,183	328,671	180,147	121,015	137,790
1983	158,732	166,888	225,451	379,089	321,367	639,739	441,612	395,519	311,269	148,590	123,446	127,651
1984	138,493	228,847	206,029	471,338	330,939	397,947	329,524	204,915	315,784	157,644	124,038	138,417
1985	146,861	160,226	152,746	136,138	143,458	175,205	265,746	183,375	150,405	92,820	119,049	147,647
1986	138,915	197,065	160,455	159,937	246,767	642,814	264,053	169,874	144,510	119,603	108,464	156,363
1987	124,331	180,833	168,296	135,223	161,785	333,348	209,754	241,988	116,995	110,152	96,540	86,960
1988	86,003	110,620	171,023	133,729	165,595	201,155	236,646	164,152	137,950	86,696	78,894	108,518
1989	116,290	176,832	183,942	172,445	184,202	211,928	378,455	237,476	115,119	105,232	109,393	107,601
1990	124,888	159,646	209,487	230,975	181,472	231,698	385,891	184,680	207,967	116,141	133,846	128,871
1991	145,381	429,155	497,371	398,718	359,640	314,386	289,066	226,436	175,923	131,910	124,748	122,923
1992	127,201	159,679	203,522	158,349	229,887	274,445	188,791	139,778	101,254	93,723	91,664	91,205
1993	100,842	123,712	117,549	128,688	133,393	213,510	198,978	188,592	102,670	90,886	85,608	100,476
1994	99,233	114,172	125,649	146,200	129,217	193,554	182,191	117,143	57,627	53,481	52,792	55,334
1995	74,280	142,044	213,254	258,499	607,181	490,575	298,106	400,306	228,945	115,951	126,834	148,686
1996	167,477	379,624	743,870	649,858	1,013,098	657,617	523,435	291,672	206,484	123,541	133,941	138,352
1997	143,505	187,184	216,784	469,615	423,661	698,484	757,634	830,130	552,947	210,364	158,922	155,549
1998	182,344	280,358	236,335	271,025	297,970	415,934	420,057	525,637	236,807	110,686	123,428	116,686
1999	130,373	157,144	255,829	365,922	233,435	318,865	341,974	411,650	442,722	291,892	149,939	136,430
2000	150,928	311,402	415,675	219,601	181,865	247,865	485,023	258,513	276,533	124,993	117,223	129,474

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2001	138,272	136,402	126,871	119,131	104,082	138,714	93,196	77,978	58,391	53,145	58,227	61,035
2002	78,498	175,107	181,669	314,356	178,969	215,588	366,222	244,157	330,168	118,278	90,376	111,466
2003	122,416	120,819	127,953	211,376	362,089	329,149	275,700	202,289	129,620	92,337	131,499	128,399
2004	142,041	162,232	186,143	173,103	183,986	294,312	227,732	133,466	97,157	104,670	153,119	148,216
2005	149,248	142,607	178,307	240,308	146,768	115,593	80,137	96,690	59,923	62,282	64,475	86,443
2006	94,939	122,489	189,945	321,119	227,862	177,622	320,627	461,553	258,432	86,882	94,599	100,221
2007	107,559	361,679	212,853	298,865	265,534	584,229	343,305	232,680	153,325	75,985	87,986	107,073
2008	130,960	145,243	220,305	142,875	167,084	209,140	138,428	410,772	126,311	101,642	92,518	106,083
2009	140,106	271,258	198,787	476,226	169,772	184,053	288,359	335,252	307,608	72,580	110,153	132,716
2010	157,608	219,422	229,467	212,413	195,150	207,752	187,646	184,631	341,201	109,755	105,193	123,443
2011	136,446	208,646	227,397	471,406	307,701	341,799	494,685	563,821	401,232	203,093	96,872	101,796
2012	134,831	151,802	144,516	225,003	268,885	337,914	627,503	488,975	412,091	177,822	112,567	114,880
2013	144,467	234,202	230,339	182,495	190,657	261,953	352,729	375,960	165,749	108,047	130,736	152,184
2014	167,834	183,900	244,454	203,578	172,513	467,361	342,895	323,871	181,066	83,862	107,888	125,391
2015	146,321	243,500	359,695	476,607	380,650	289,942	155,232	95,428	59,225	56,148	61,042	65,889
2016	90,551	267,001	405,917	230,214	510,077	635,981	567,053	358,108	105,490	77,880	94,308	115,374
2017	194,888	222,311	149,691	153,573	225,471	593,133	574,411	422,677	278,294	73,890	100,797	108,553
2018	161,606	262,467	221,221	244,442	333,388	204,113	322,095	524,734	75,850	58,357	83,098	112,866

Table C-2. Modified flows of the Yakima River at the mouth for water years 1926 through 2018 (cfs)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1926	2,064	2,471	3,521	3,311	3,390	4,568	2,989	1,535	1,315	1,108	1,047	1,159
1927	2,042	2,767	4,406	3,124	3,209	3,961	4,912	5,791	6,111	2,108	1,693	1,684
1928	2,992	6,570	7,143	7,537	3,730	5,258	4,721	7,879	3,086	1,814	1,513	1,722
1929	2,304	2,792	2,485	2,354	2,385	2,807	1,763	2,766	2,336	1,629	1,461	1,420
1930	2,041	2,450	2,167	2,062	3,273	3,019	4,013	1,629	1,739	1,355	1,252	1,215
1931	1,668	2,436	2,076	2,015	3,072	2,812	1,861	2,692	1,797	1,276	1,166	1,178
1932	1,530	2,789	2,375	3,054	3,165	7,851	5,288	4,398	4,282	2,002	1,519	1,681
1933	2,153	5,238	4,752	4,597	2,851	3,227	5,814	6,145	7,456	4,779	2,070	2,187
1934	2,960	6,348	19,527	14,306	7,548	10,599	8,457	4,352	1,696	1,492	1,626	1,776
1935	2,531	5,362	4,043	6,030	5,965	3,990	3,124	3,714	5,850	2,039	1,815	2,023
1936	2,085	2,542	2,203	2,397	2,224	3,398	6,264	6,225	5,856	1,739	1,625	1,803
1937	1,883	2,202	2,209	1,934	1,822	2,995	3,505	2,779	4,471	2,097	1,981	2,255
1938	1,933	3,378	4,544	4,908	3,335	5,842	8,068	6,437	5,954	2,070	1,936	1,901
1939	1,989	2,582	2,834	3,190	2,462	3,212	2,783	1,894	1,908	1,481	1,519	1,627
1940	1,770	2,119	2,660	2,362	3,190	4,559	3,450	2,519	1,700	1,478	1,573	1,712
1941	1,834	2,273	2,913	2,449	2,601	3,207	2,558	1,438	1,602	1,385	1,437	1,611
1942	1,638	2,512	3,624	2,285	2,719	2,671	2,470	2,270	2,069	1,633	1,576	1,639
1943	1,739	2,867	3,927	3,836	3,597	3,871	10,085	4,102	3,677	3,400	2,090	1,896

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1944	2,263	2,605	2,799	2,149	2,130	2,262	1,372	1,401	1,755	1,520	1,552	1,578
1945	1,665	2,130	2,159	3,138	3,411	2,227	1,811	2,631	2,398	1,598	1,855	1,759
1946	1,781	2,436	2,487	3,362	2,518	3,849	5,341	7,161	5,316	2,230	1,972	2,352
1947	2,438	2,778	6,518	3,779	4,796	5,428	4,531	5,101	3,614	1,910	1,969	2,177
1948	3,279	4,256	3,815	3,480	3,490	3,493	4,426	7,168	14,565	2,639	2,288	2,235
1949	2,529	2,920	2,820	2,334	3,097	5,704	8,364	9,986	6,741	2,109	2,264	2,281
1950	2,614	3,904	4,345	3,140	3,425	7,945	7,925	8,810	10,739	5,188	2,102	1,945
1951	2,770	5,301	8,975	6,202	9,204	7,545	10,709	9,243	6,436	2,123	2,087	2,386
1952	2,883	3,061	3,194	2,404	3,632	3,417	4,118	3,463	2,432	2,076	2,103	2,202
1953	2,048	2,262	2,252	5,073	5,857	3,285	2,399	4,363	3,947	1,995	2,110	2,151
1954	2,273	2,637	4,061	3,391	4,082	4,398	5,405	8,509	5,269	4,753	2,395	2,457
1955	2,792	3,626	3,238	2,712	2,954	2,279	2,685	3,334	6,651	3,147	2,111	2,319
1956	2,929	5,557	7,140	5,429	3,690	9,560	15,027	16,013	10,042	3,962	2,523	2,780
1957	2,878	3,182	6,823	3,010	2,958	4,302	6,824	8,673	3,080	1,656	1,859	2,148
1958	2,678	2,592	2,792	2,949	4,796	4,537	5,442	5,926	2,185	1,505	1,656	2,066
1959	2,083	5,350	6,483	6,717	4,755	5,106	6,204	4,094	5,223	1,892	1,875	2,661
1960	3,528	6,617	7,141	3,915	3,721	4,824	7,399	3,679	3,891	1,412	1,857	2,228
1961	2,339	3,226	3,019	3,580	6,904	6,437	7,275	6,748	7,697	1,582	1,847	1,923
1962	2,334	2,688	3,008	4,685	4,478	3,093	5,223	2,843	2,298	1,718	1,728	1,999
1963	2,684	4,598	5,196	3,845	6,888	3,951	4,409	2,964	1,732	1,749	1,788	1,988
1964	1,989	2,629	2,739	2,809	2,777	2,535	2,524	2,626	5,077	1,918	2,027	2,029
1965	2,323	2,651	4,428	4,853	9,507	6,071	7,572	4,787	4,718	1,902	1,987	2,203
1966	2,317	2,573	2,562	2,623	2,294	3,382	5,177	3,060	2,139	1,930	1,598	1,974
1967	2,077	2,590	4,209	3,693	4,345	2,791	2,045	4,325	6,099	2,070	1,621	1,696
1968	2,326	3,405	3,908	5,469	7,256	6,900	2,013	2,574	2,984	1,496	2,006	2,374
1969	2,443	3,795	3,589	3,876	3,008	5,109	7,489	7,956	5,969	1,720	1,789	2,068
1970	2,256	2,363	2,477	3,483	4,217	4,200	3,113	3,498	3,948	1,356	1,595	1,968
1971	2,169	2,548	2,854	5,186	7,225	3,869	4,887	8,712	6,163	2,812	1,862	2,702
1972	2,546	2,869	2,987	4,010	5,782	17,849	9,698	14,631	11,242	4,220	2,222	2,392
1973	2,546	2,664	4,679	5,394	3,011	2,784	1,826	1,744	1,507	1,010	1,182	1,423
1974	1,921	3,774	4,813	11,271	6,092	5,897	8,771	8,462	11,166	5,662	2,190	2,374
1975	2,489	2,517	3,688	5,595	4,448	5,557	4,943	8,115	7,407	3,585	2,266	2,399
1976	2,540	3,768	12,129	8,550	5,059	4,888	7,007	7,181	3,594	2,625	2,409	2,438
1977	2,574	2,404	2,489	3,059	2,297	1,712	1,040	1,037	993	972	1,079	1,650
1978	1,682	3,020	11,837	4,825	4,894	6,743	6,531	3,625	2,508	2,144	1,848	2,106
1979	1,948	2,399	2,535	2,127	2,981	3,552	2,407	2,003	1,313	1,132	1,142	1,153
1980	1,239	2,229	3,836	3,204	3,442	6,440	6,342	5,058	2,493	2,027	1,875	2,183
1981	2,007	2,957	7,349	6,766	6,852	4,708	2,041	1,910	1,785	1,546	1,380	1,717
1982	2,235	2,632	3,297	4,161	8,831	6,851	4,342	4,784	5,523	2,930	1,968	2,316
1983	2,582	2,805	3,667	6,165	5,787	10,404	7,422	6,432	5,231	2,417	2,008	2,145



Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1984	2,252	3,846	3,351	7,666	5,753	6,472	5,538	3,333	5,307	2,564	2,017	2,326
1985	2,388	2,693	2,484	2,214	2,583	2,849	4,466	2,982	2,528	1,510	1,936	2,481
1986	2,259	3,312	2,610	2,601	4,443	10,454	4,438	2,763	2,429	1,945	1,764	2,628
1987	2,022	3,039	2,737	2,199	2,913	5,421	3,525	3,936	1,966	1,791	1,570	1,461
1988	1,399	1,859	2,781	2,175	2,879	3,271	3,977	2,670	2,318	1,410	1,283	1,824
1989	1,891	2,972	2,992	2,805	3,317	3,447	6,360	3,862	1,935	1,711	1,779	1,808
1990	2,031	2,683	3,407	3,756	3,268	3,768	6,485	3,004	3,495	1,889	2,177	2,166
1991	2,364	7,212	8,089	6,485	6,476	5,113	4,858	3,683	2,956	2,145	2,029	2,066
1992	2,069	2,683	3,310	2,575	3,997	4,463	3,173	2,273	1,702	1,524	1,491	1,533
1993	1,640	2,079	1,912	2,093	2,402	3,472	3,344	3,067	1,725	1,478	1,392	1,689
1994	1,614	1,919	2,043	2,378	2,327	3,148	3,062	1,905	968	870	859	930
1995	1,208	2,387	3,468	4,204	10,933	7,978	5,010	6,510	3,848	1,886	2,063	2,499
1996	2,724	6,380	12,098	10,569	17,613	10,695	8,797	4,744	3,470	2,009	2,178	2,325
1997	2,334	3,146	3,526	7,638	7,628	11,360	12,732	13,501	9,293	3,421	2,585	2,614
1998	2,966	4,712	3,844	4,408	5,365	6,765	7,059	8,549	3,980	1,800	2,007	1,961
1999	2,120	2,641	4,161	5,951	4,203	5,186	5,747	6,695	7,440	4,747	2,439	2,293
2000	2,455	5,233	6,760	3,571	3,162	4,031	8,151	4,204	4,647	2,033	1,906	2,176
2001	2,249	2,292	2,063	1,937	1,874	2,256	1,566	1,268	981	864	947	1,026
2002	1,277	2,943	2,955	5,113	3,223	3,506	6,155	3,971	5,549	1,924	1,470	1,873
2003	1,991	2,030	2,081	3,438	6,520	5,353	4,633	3,290	2,178	1,502	2,139	2,158
2004	2,310	2,726	3,027	2,815	3,199	4,787	3,827	2,171	1,633	1,702	2,490	2,491
2005	2,427	2,397	2,900	3,908	2,643	1,880	1,347	1,573	1,007	1,013	1,049	1,453
2006	1,544	2,058	3,089	5,223	4,103	2,889	5,388	7,506	4,343	1,413	1,539	1,684
2007	1,749	6,078	3,462	4,861	4,781	9,502	5,769	3,784	2,577	1,236	1,431	1,799
2008	2,130	2,441	3,583	2,324	2,905	3,401	2,326	6,681	2,123	1,653	1,505	1,783
2009	2,279	4,559	3,233	7,745	3,057	2,993	4,846	5,452	5,170	1,180	1,791	2,230
2010	2,563	3,688	3,732	3,455	3,514	3,379	3,153	3,003	5,734	1,785	1,711	2,075
2011	2,219	3,506	3,698	7,667	5,540	5,559	8,313	9,170	6,743	3,303	1,575	1,711
2012	2,193	2,551	2,350	3,659	4,675	5,496	10,546	7,952	6,925	2,892	1,831	1,931
2013	2,350	3,936	3,746	2,968	3,433	4,260	5,928	6,114	2,786	1,757	2,126	2,558
2014	2,730	3,091	3,976	3,311	3,106	7,601	5,763	5,267	3,043	1,364	1,755	2,107
2015	2,380	4,092	5,850	7,751	6,854	4,715	2,609	1,552	995	913	993	1,107
2016	1,473	4,487	6,602	3,744	8,868	10,343	9,530	5,824	1,773	1,267	1,534	1,939
2017	3,170	3,736	2,434	2,498	4,060	9,646	9,653	6,874	4,677	1,202	1,639	1,824
2018	2,628	4,411	3,598	3,975	6,003	3,320	5,413	8,534	1,275	949	1,351	1,897

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