

6.0 WATER BUDGET

6.1 INTRODUCTION

In 1998 the Entiat WRIA Planning Unit (EWPU) applied for funds from the State of Washington under Chapter 90.82 RCW, the Watershed Planning Act. In doing so, it agreed to develop a water budget for the Entiat Water Resource Inventory Area (WRIA 46), which comprises the Entiat River watershed, the Mad River watershed, and some minor Columbia River tributaries. A water budget is basically an accounting ledger that contains water credits and debits, i.e. an estimate of water present within the system (credit); what water is needed to accommodate future domestic, commercial and agricultural use (debit); what flows are required to be left in stream for the protection of *existing* beneficial uses, including water for irrigation and fish (debit); and what actual water use is occurring (debit).

The difference between the credit and debit numbers shows what water is available during different months of the year for future appropriation. The information contained in the water budget will allow the EWPU to make management recommendations to WDOE about how much water should be made available in the future for new water rights associated with commercial enterprises, agriculture, residential development, and other beneficial uses. Through the use of its water budget, the EWPU will be able to provide the State the maximum possible input regarding the protection of existing water rights, strategies for water resource management, and issuance of new water rights in WRIA 46.

6.2 WATER BUDGET FORMAT

A primary reason for development of a water budget is to determine at what times of year water resources are scarce and/or require management. Consequently, the EWPU water budget shows flow and water use data by month, with semi-monthly values added as necessary due to administrative instream flow recommendations.

WRIA 46 is composed of two main drainages, the Entiat and Mad River watersheds, as well as an area containing minor Columbia River tributaries. A water budget spreadsheet was developed for each of the major drainage areas in the WRIA (Entiat River, Mad River, and minor Columbia River tributaries); the Entiat River was also split into upper and lower reaches. Dividing the WRIA into four different areas was done to facilitate estimation of the amount of water present and actual water use, as well as the development of instream flow and water management recommendations. Channel geomorphology, fish habitat and use, land and water use, settlement patterns, and the hydrologic connectivity of these areas, as well as where administrative instream flows would be monitored, were all used to help determine how to split the WRIA.

6.3 DATA INPUTS

A number of studies were sponsored by the EWPU to collect data for use in the development of its water budget. Data from a number of sources, including stream gage records, in-field flow measurements, and Geographic Information System (GIS) modeling of aquifer thickness and extent were used. These studies and data have been detailed previously in [Chapter 4](#), Water Quantity.

Entiat and Mad River streamflows were estimated by assembling and analyzing all existing stream flow data from USGS gages, and developing synthesized stream flow records that include modeled flow data for those years in which no data were available. A base flow separation analysis was done to determine what contribution groundwater makes to the total flow in the river at different times throughout the year.

A better understanding of surface and ground water interaction/connectivity in the Entiat and Mad River watersheds was gained by monitoring residential well levels and examining how those levels, especially water levels in wells drilled into the alluvium, responded to changes in stream flow. A gain-loss study was also done to identify stream reaches in which surface-ground water interaction was occurring.

Fruit tree irrigation requirement data and land use acreages were used to estimate current irrigation water use by month occurring within the WRIA. Data on weekly average tree water use over a 25-year period were used to develop a ratio of semi-monthly to monthly water use, which was then applied to monthly tree water use estimates in order to derive select semi-monthly tree water use values.

Population data were used in conjunction with City of Entiat water pumping, use and connection records to estimate daily in-house net water use. Census block information and population projections were used to estimate how much water will be needed in the future to ensure community growth and development.

The Planning Unit and ENTRIX, Inc. developed Planning Unit Instream Flow as well as Administrative Instream Flow recommendations to protect existing resources and beneficial uses, and to help guide issuance of new rights based on all of the aforementioned data. Refer to [Chapter 5](#) for these flow regimes.

6.4 UPPER ENTIAT RIVER BUDGET

Flows for the upper Entiat River are monitored at the Stormy gage (Entiat near Ardenvoir USGS gage, at RM 18). It was estimated that water use occurring upstream of this point is associated with the irrigation of approximately 20 acres of residential property (lawn), and totals only 80 acre-feet annually. Average peak monthly use in July accounts for approximately 20 acre-feet, which is negligible in comparison to the average July monthly volume of stream flow produced by the entire subbasin (46,955 acre-feet, based on composite Keystone gage record).

The tables on pages 6-4 and 6-5 show mean monthly and/or semi-monthly flow recorded at the Stormy gage in cfs and acre-feet, respectively, as well as the estimated water use occurring upstream of this point. The “Naturalized” mean stream flow number is meant to approximate what stream flow would likely be recorded at the Stormy gage if no upstream water use were occurring in the subbasin. The difference between proposed Administrative Instream Flows and monthly mean (or semi-monthly mean) stream flow shows the amount of water that will potentially available for future appropriation if the proposed Administrative Instream flows are codified. In some months, the amount of water potentially available for future appropriation will be limited to a specific number of cfs as recommended by the WDOE.

Table 6-1. Upper Entiat River water budget (cfs), tied to the Stormy gage (USGS gage #12452800, Entiat near Ardenvoir).

	Jan 1-31	Feb 1-28	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-31	Jun 1-30	Jul 1-15	Jul 16-31	Aug 1-31	Sep 1-30	Oct 1-31	Nov 1-30	Dec 1-31
"Naturalized" mean streamflow (cfs) at Stormy gage	106	114	131	167	243	410	1068	1431	813	481	219	114	100	129	126
Orchard irrigation water use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lawn irrigation water use - 20 acres	0	0	0	0	0.03	0.09	0.16	0.27	0.34	0.33	0.27	0.15	0.07	0	0
Domestic net water use* - 115 housing units according to census	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Mean streamflow (cfs) at Stormy gage	106	114	131	167	243	410	1068	1431	813	481	219	114	100	129	126
Proposed Administrative MIF	175	175	175	285	325	375	375	325	275	275	275	175	175	175	175
Water potentially available for future appropriation	-69	-61	-44	-118	-82	35	693	1106	538	206	-56	-61	-75	-46	-49
Water available for future appropriation* (cfs)	0	0	0	0	0	35	100	100	67	206	0	0	0	0	0

* *Italicized* water amounts will be based on codification of WDOE's determination of water availability during select semi-monthly periods.

Conversions/Assumptions used in calculations:

"Naturalized" = gage discharge + use totals (rounded as appropriate)

1 cfs for 1 day = 1.9835 acre-feet

1 housing unit = 2.71 people per unit

Net water use = 35 gallons per capita per day

325,850 gallons = 1 acre-foot

Table 6-2. Upper Entiat River water budget (acre-feet), tied to the Stormy gage (USGS gage #12452800, Entiat near Ardenvoir).

	Jan 1-31	Feb 1-28	Mar 1-15	Mar 6-31	Apr 1-15	Apr 16-30	May 1-31	Jun 1-30	Jul 1-15	Jul 16-31	Aug 1-31	Sep 1-30	Oct 1-31	Nov 1-30	Dec 1-31
"Naturalized" mean volume (ac- ft) at Stormy gage	6518.82	6332.27	3898.08	5300.45	7231.23	12201.78	65680.64	85168.89	24199.30	15276.15	13483.79	6793.57	6154.21	7677.15	7748.59
Orchard irrigation water use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lawn irrigation water use - 20 acres	0	0	0	0	0.88	2.75	9.88	16.23	10.02	10.59	16.77	9.00	4.32	0	0
Domestic net water use - 115 housing units according to census	1.04	0.94	0.50	0.54	0.50	0.50	1.04	1.00	0.50	0.54	1.04	1.00	1.04	1.00	1.04
Mean volume (ac- ft) at Stormy gage	6517.78	6331.33	3897.58	5299.91	7229.86	12198.53	65669.72	85151.66	24188.78	15265.02	13465.98	6783.57	6148.85	7676.15	7747.55
Proposed Administrative MIF	10760.49	9719.15	10760.49	17524.22	9669.56	11157.19	23058.19	19339.13	8181.94	8727.40	16909.34	10413.38	10760.49	10413.38	10760.49
Water potentially available for future appropriation	-4242.71	-3387.82	-6862.91	-12224.31	-2439.71	1041.34	42611.53	65812.53	16006.85	6537.62	-3443.36	-3629.81	-4611.64	-2737.23	-3012.94
Water available for future appropriation (ac- ft)	0	0	0	0	0	1041	6149	5951	1993	6538	0	0	0	0	0

6.5 LOWER ENTIAT RIVER BUDGET

Flows in the lower Entiat River are monitored at the Keystone gage (USGS gage #1245990, Entiat near Entiat), located approximately 1.4 miles upstream of the Entiat's confluence with the Columbia River. In this portion of the Entiat River watershed irrigation water use accounts for almost all use occurring in the subbasin. Peak net irrigation water use by occurs in July, with average monthly irrigation use totaling 1511 acre-feet (about 25 cfs), or 3% of the average monthly volume of water produced during this month (47,039 acre-feet or approximately 765 cfs). Average net irrigation water use in the months of September and October is approximately 6.5% and 6%, respectively, of the average monthly volume of water produced during these months. Actual gross water use is greater due to water conveyance losses.

As the Keystone gage site is essentially the "pour point" for the entire Entiat subbasin, the water budget tables for the lower Entiat River on pages 6-7 and 6-8 reflect all upstream water uses recorded within the subbasin. Again, the "Naturalized" mean flow approximates what stream flow would be recorded at the Keystone gage were no upstream water use occurring. Additionally, water use associated with residences found in the lower Mad River was included as part of the lower Entiat River use, due to the following reasons:

- There is a high degree of connectivity between surface and ground water in the Entiat subbasin;
- There is very minimal private land ownership upstream of RM 2 in the Mad River;
- The primary domestic water source in the lower Mad River is wells; and
- The lower Mad River and area around its mouth are part of an alluvial fan, and therefore groundwater drawn from the lower Mad River is likely a part of the larger unconsolidated alluvial valley aquifer.

Table 6-3. Lower Entiat River water budget (cfs), tied to the Keystone gage (USGS gage #12452990, Entiat near Entiat).

	Jan 1-30	Feb 1-28	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun 1-15	Jun 16-30	Jul 1-15	Jul 16-31	Aug 1-31	Sept 1-30	Oct 1-31	Nov 1-30	Dec 1-31
"Naturalized" mean flow (cfs)	164	176	198	248	342	545	1019	1571	1886	1524	985	607	308	181	161	189	187
Upper Entiat orchard irrigation water use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Entiat lawn irrigation water use - 20 acres	0	0	0	0	0.03	0.09	0.15	0.17	0.23	0.32	0.34	0.33	0.27	0.15	0.07	0	0
Upper Entiat domestic net water use - 115 housing units	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Lower Entiat orchard irrigation water use - 835	0	0	0	0	1.46	4.59	7.28	8.62	11.21	15.85	16.70	16.56	13.53	7.50	3.48	0	0
Lower Entiat pasture/lawn irrigation water use - 407 acres	0	0	0	0	0.60	1.90	3.02	3.58	4.65	6.58	6.93	6.49	5.61	3.11	1.44	0	0
Lower Entiat/Mad domestic net water use - 355 housing units	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Mad orchard irrigation water use - 21 acres	0	0	0	0	0.04	0.12	0.18	0.22	0.17	0.40	0.42	0.42	0.34	0.19	0.09	0	0
Mad lawn irrigation water use - 15 acres	0	0	0	0	0.03	0.08	0.13	0.16	0.20	0.29	0.30	0.30	0.25	0.14	0.06	0	0
Mean flow (cfs) at Keystone gage	164	176	198	248	340	538	1008	1558	1869	1500	960	583	288	170	156	189	187
Proposed Administrative MIF	185	185	185	250	250	350	474	720	898	617	359	268	185	185	185	185	185
Water potentially available for future appropriation	-21	-9	13	-2	90	188	534	838	971	883	601	315	103	-15	-29	4	2
Water available (cfs) for future appropriation	0	0	13	0	90	188	100	100	100	100	67	315	103	0	0	4	2

Table 6-4. Lower Entiat River water budget (acre-feet), tied to the Keystone gage (USGS gage #12452990, Entiat near Entiat).

	Jan 1-30	Feb 1-28	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun 1-15	Jun 16-30	Jul 1-15	Jul 16-31	Aug 1-31	Sep 1-30	Oct 1-31	Nov 1-30	Dec 1-31
"Naturalized" mean volume (ac-ft)	10088	9778	5893	7873	10182	16211	30313	49851	56099	45328	29299	19269	18942	10780	9913	11250	11502
Upper Entiat orchard irrigation water use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Entiat lawn irrigation water use - 20 acres	0	0	0	0	0.88	2.75	4.37	5.51	6.72	9.51	10.02	10.59	16.77	9.00	4.32	0	0
Upper Entiat domestic net water use - 115 housing units	1.04	0.94	0.50	0.54	0.50	0.50	0.50	0.54	0.50	0.50	0.50	0.54	1.04	1.00	1.04	1.00	1.04
Lower Entiat orchard irrigation water use - 835 acres	0	0	0	0	43.37	136.47	216.74	273.55	333.40	471.62	496.83	525.50	831.78	446.4	214.1	0	0
Lower Entiat pasture/lawn irrigation water use - 407 acres	0	0	0	0	17.99	56.61	89.90	113.47	138.29	195.63	206.09	206.09	345.02	185.16	88.81	0	0
Lower Entiat/Mad domestic net water use - 355 housing units	3.2	2.9	1.49	1.59	1.49	1.49	1.49	1.59	1.49	1.49	1.49	1.59	3.2	3.1	3.2	3.1	3.2
Mad orchard irrigation water use - 21 acres	0	0	0	0	1.10	3.46	5.49	6.93	4.92	11.95	12.59	13.31	21.07	11.31	5.42	0	0
Mad lawn irrigation water use - 15 acres	0	0	0	0	0.79	2.47	3.93	4.97	6.05	8.56	9.02	9.54	15.1	8.1	3.89	0	0
Mean volume (ac-ft) at Keystone gage	10084.11	9774.69	5891.00	7870.53	10115.85	16006.85	29990.52	49444.69	55607.42	47604.00	28562.40	18502.09	17708.69	10115.85	9592.21	11246.45	11498.35
Proposed Administrative MIF	11375.37	10274.53	5504.21	7934.00	7438.125	10413.38	14102.69	22849.92	26717.75	18357.29	10681.15	8505.25	11375.37	11008.43	11375.37	11008.43	11375.37
Water potentially available for future appropriation	-1291.26	-499.84	386.78	-63.47	2677.73	5593.47	15887.84	26594.77	28889.68	29246.71	17881.25	9996.84	6333.32	-892.57	-1783.17	238.02	122.98
Water available for future appropriation (ac-ft)	0	0	387	0	2678	5593	2975	3174	2975	2975	1993	9997	6333	0	0	238	123

6.6 MAD RIVER BUDGET

Table 6-5. Mad River water budget (cfs), tied to USGS gage #12452890, Mad at Ardenvoir.

	Jan 1-31	Feb 1-28	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-31	Jun 1-30	Jul 1-31	Aug 1-15	Aug 16-31	Sep 1-30	Oct 1-31	Nov 1-30	Dec 1-31
Mean streamflow (cfs)	27	37	53	53	135	135	321	250	93	43	43	27	25	29	30
Proposed Administrative MIF	32	32	32	68	100	100	100	100	68	68	51	32	32	32	32
Water potentially available (cfs) for future appropriation	-5	5	21	-15	35	35	221	150	25	-25	-8	-5	-7	-3	-2
Water available (cfs) for future appropriation	0	5	21	0	35	25	25	25	25	0	0	0	0	0	0

Table 6-6. Mad River water budget (acre-feet), tied to USGS gage #12452890, Mad at Ardenvoir.

	Jan 1-31	Feb 1-28	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-31	Jun 1-30	Jul 1-31	Aug 1-15	Aug 16-31	Sep 1-30	Oct 1-31	Nov 1-30	Dec 1-31
Mean volume (ac-ft) at Mad gage	1660.19	2054.91	1576.88	1682.01	4016.59	4016.59	19737.81	14876.25	5718.43	2644.01	2644.01	1606.64	1537.21	1725.65	1844.66
Proposed Administrative MIF	1967.63	1777.22	952.08	2158.05	2975.25	2975.25	6148.85	5950.50	4181.22	4181.22	3135.91	1904.16	1967.63	1904.16	1967.63
Water potentially available for future appropriation	-307.44	277.69	624.80	-476.04	1041.34	1041.34	13588.96	8925.75	1537.21	-1537.21	-491.91	-297.53	-430.42	-178.52	-122.98
Water available for future appropriation	0	278	625	0	1041	744	1537	1488	1537	0	0	0	0	0	0

6.7 MINOR COLUMBIA RIVER TRIBUTARIES BUDGET

This water budget addresses the minor, often ephemeral streams above the Entiat River-Columbia River confluence as far north as Oklahoma Gulch and below the confluence as far south as Swakane Canyon (both drainages included). These drainages, though encompassed within the Entiat WRIA, flow directly into the Columbia River. Much of their area is either state (WDFW) or federally (USFS) owned; private property (excluding the City of Entiat) is largely concentrated in a narrow strip along the Columbia River and astride State Highway 97A.

Precipitation in the minor Columbia River Tributaries (CRT) ranges from 8 to 36 inches annually (Daly and Taylor 1998), with the higher values limited to the upper portions of the Swakane Creek drainage, which extends much further west and into higher elevations than the other CRT. Table 6-7 lists the surface area, average (area-weighted) annual precipitation and selected surface water discharges (at or near peak flow conditions) for the minor CRTs.

Table 6-7. Summary of minor Columbia River tributary precipitation and select surface flows.

Drainage Name	Area (acres)	Average Precipitation (inches)	Precipitation volume (ac-ft)	Surface Flow (cfs) 3/27/2003	Annual Runoff (ac-ft)¹
Oklahoma Gulch	3047	19.2	4887	0.76	549
Byrd Canyon	2243	18.3	3416	0.72	520
McKinstry Canyon	1172	18.9	1849	0.38	275
Spencer Canyon	2816	19.7	4614	N/A	N/A
Tenas George Canyon	3869	22.3	7204	0.13	94
Swakane Canyon	13639	27.9	31662	0.41	296
sub-total	26785		53632		1734
Other CRTs	8736	22.0	16020		
Total	35521		69652		

¹ Maximum estimated value based on continuous 3/27 flow rate for one year.

It is clear from the table that the vast majority of precipitation falling within the CRT is either lost to evapotranspiration or penetrates into the surface to become groundwater. Although some of the CRTs, notably Oklahoma Gulch, Byrd and McKinstry Canyons, are perennial, the total surface contribution of these streams to the Columbia River (if they were to run at or near peak flow rates all year) would be a very small fraction of total annual precipitation.

Groundwater within or near the CRT has as its source(s): 1) saturated Columbia River alluvial sediment; 2) shallow, localized unconsolidated or bedrock aquifers; or 3) deeper and/or more laterally extensive bedrock aquifers. In any case, such water is not immediately connected to the Entiat subbasin system, nor is any surface flow from these drainages connected to or influenced by the Entiat system. Furthermore, water contributions to the Columbia River from the Entiat WRIA minor CRTs fall under the management and regulatory scope of WAC 173-563 (see [Appendix L](#)). For these reasons, and considering the limited potential for future residential/agricultural development of this area, the EWPU did not perform as rigorous an examination of water quantity in the CRTs.