EFFECTS OF HUMAN WATER USE ON NOOKSACK STREAMFLOWS[1]

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Climate change is dramatically affecting seasonal flows of water throughout the Nooksack watershed, with substantial declines in summer flows. These declines are virtually certain to continue for the next few decades.[2] We need to better understand how these much lower flows will affect fish and other wildlife as well as water use, especially agriculture.

Climate change also increases the need for irrigation because summers are hotter and drier. We need to better understand how these temperature and rainfall changes affect irrigation.

The water rights adjudication now underway will, within a decade or two, determine who has the right to use water, when, where and in what amounts. This legal process should be informed by the current and projected relationships between available supplies and demands.

When the Washington Dept. of Ecology (Ecology) issued its instream flow rule in 1985, it was officially clear that water supplies in the Nooksack River basin were limited.[3] Since then, the relationships between out-of-stream water use and streamflows in the watershed have been an important issue. In particular, summer streamflows are often insufficient to meet Ecology's minimum flows, worsening conditions for salmon and other wildlife.

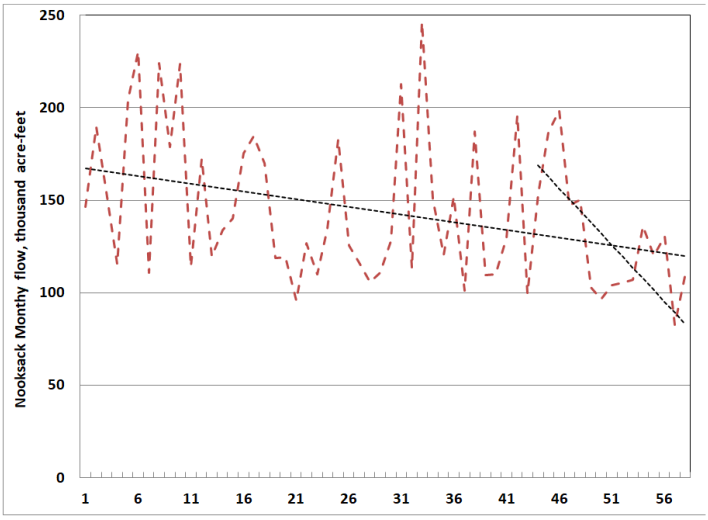

Fig. 1. Summer flows in the Nooksack River at Ferndale. The straight lines are the trends for the entire 58 years and for the last 15 years.

I explore the relationships between streamflows and out-of-stream water use for the mainstem Nooksack River at Ferndale and for Fishtrap and Bertrand creeks near their confluences with the mainstem. I chose these locations because the mainstem at Ferndale is only five

[1] I thank Jim Davenport for suggesting this issue for analysis and for his guidance during the course of its execution. I thank Doug Allen, Larry Davis, Dan Eisses, Jim Hansen, Chris Heimgartner, Hank Kastner, Dan Raas, and Gavin Willis for their helpful comments on a draft of this paper.
[2] E. Hirst, *Climate Change and the Nooksack Adjudication*, April 2024.
[3] Washington State Dept. of Ecology, *Instream Resources Protection Program—Nooksack Water Resource Inventory Area (WRIA) 1*, Chapter 173-501 WAC, June 9, 1988.

miles from the river's outlet in Bellingham Bay; thus data from this location roughly represent the watershed as a whole. Fishtrap and Bertrand creeks are at the other end of the spectrum, small tributaries to the mainstem, dominated by agricultural irrigation.

I focus on summer (July, August, September) because that is when flows are the lowest and human use of water is the greatest.[4] As explained in the Appendix, the lack of data on irrigation water use and complexities of groundwater flows limit the accuracy of results developed here.

NOOKSACK RIVER

I analyzed monthly data from the U.S. Geological Survey (USGS) gauge for the period 1967 through 2024 (58 years).I converted the measurements from cubic feet per second to acre-feet per month to allow comparisons with estimates of water use. As discussed elsewhere, the trends for summer flow are downward (Fig. 1).[5] During the last 15 years (2010 – 2024), flows declined by almost 4%/year.

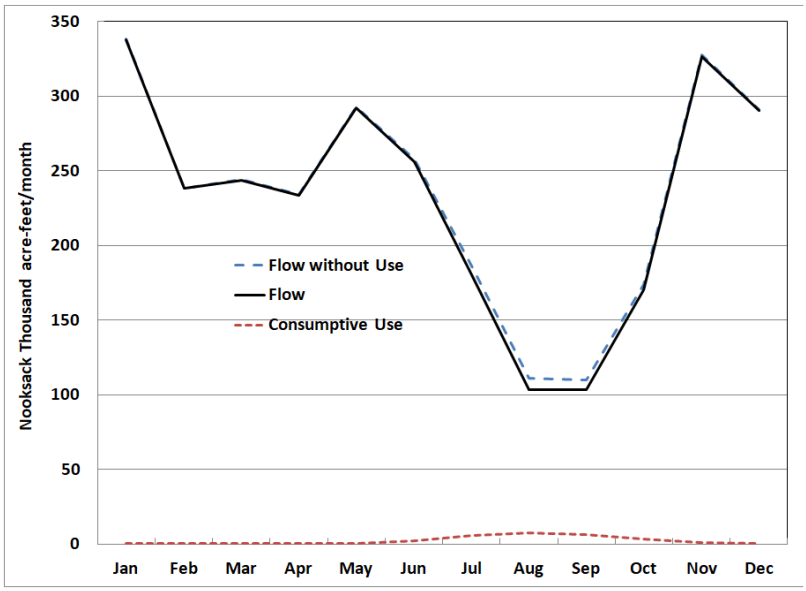

Fig. 2. Monthly flows in the Nooksack River and estimated out-of-stream consumptive water use. The dashed blue line shows how much higher flows would have been with no water use.

Monthly flows vary greatly (Fig. 2), with summer flows averaging about 60% of annual flows.[6] The figure also shows estimated monthly consumptive water use,[7] explained in the Appendix. For most of the year, human water use is a small fraction of instream flow (1.1% on average), but during the summer months water use averages 5% of

[4] *Human* water use means all out-of-stream uses, including residential, commercial, industrial, and agricultural. uses.

[5] E. Hirst, "Nooksack Watershed Summer Water Temperature Trends," *Whatcom Watch*, 33(12), Dec. 2024. During recent years the downward trend in summer flows throughout the watershed has accelerated, worsening conditions for salmon.

[6] For consistency across the three watersheds, comparisons use flow data from the last 15 years only, 2010 – 2024.

[7] Consumptive water use is the amount of water withdrawn or diverted that is *not* returned to aquifers or streams. Consumptive use for irrigation is caused by evaporation and transpiration. According to USGS, "Consumptive use is the part of water withdrawn that is evaporated, transpired, incorporated in products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment" (L. Medalie et al., *Water Use Across the Conterminous United States, Water Years 2010–20, Chapter D of U.S. Geological Survey Integrated Water Availability Assessment—2010–20*, 2025).

flow, reaching a peak of 8% in August.[8]

FISHTRAP CREEK

Data for Fishtrap Creek are available for 26 years, 1999 through 2024 (Fig. 3).[9] Here, too, the trends in streamflow are negative: -7.6%/year for summer flow over the past 15 years. Monthly flows vary much more than for the mainstem: the volume flowing during the summer is only 16% of the yearly average (Fig. 4).

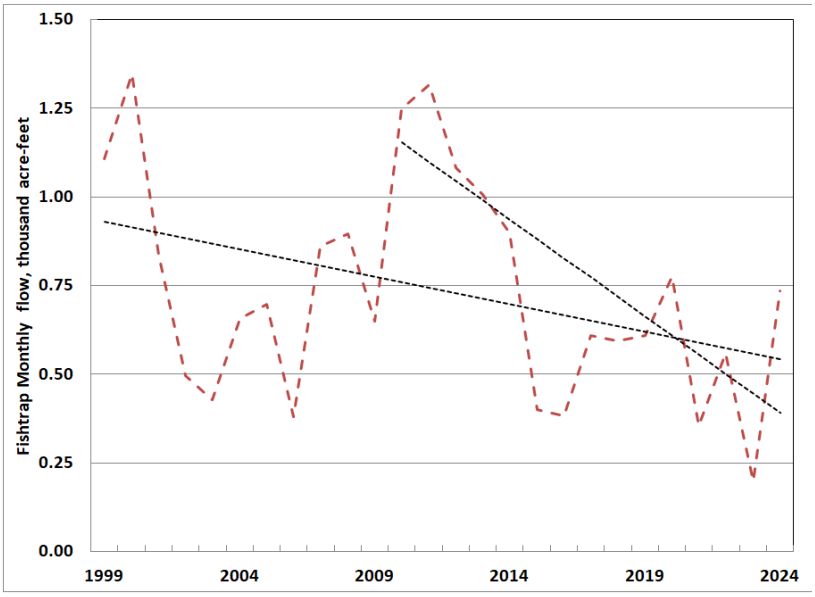

Fig. 3. Summer flows in Fishtrap Creek.

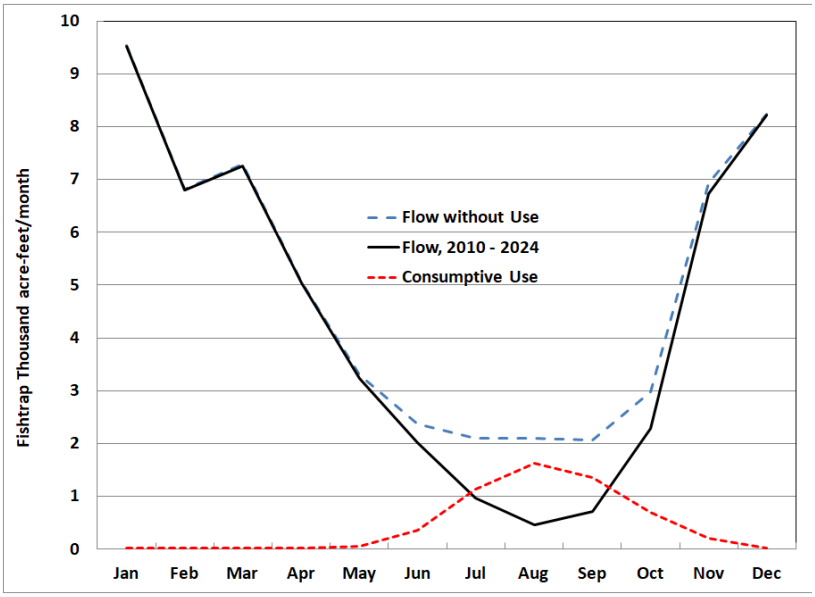

Fig. 4. Monthly flows in Fishtrap Creek and estimated water use.

Averaged over the full year, out-of-stream water use is 10% of instream flow. But during the summer, human use (primarily irrigation) is almost two-thirds of the total water available (water use plus actual streamflow). And in August, water use is three-fourths of total water.

BERTRAND CREEK

Data for Bertrand Creek are available from an Ecology station for the 22-year period from 2003 through 2024 (Fig. 5). Summer flows declined at 2.3%/year.

[8] The effects of water use on streamflows may be less than shown here because parts of Whatcom County lie outside the boundaries of the Nooksack watershed, such as Dakota and California creeks and Lake Whatcom. As a counter, RH2 Engineering estimated 2020 consumptive water use for all of WRIA 1 as 116,400 acre-feet, more than double the estimate used here (RH2 Engineering, *Regional Water Supply Plan – Phase 2 Report*, Jan. 2023).

[9] Unlike the mainstem, which is fed by glaciers and snowfall, Fishtrap and Bertrand creeks flow south from lower British Columbia and are affected primarily by human and natural actions there.

Monthly flows vary considerably, as with Fishtrap Creek. Summer volumes are 12% of the annual average, and August flows are only 9% of the annual average (Fig. 6).

Averaged over the full year, human water use is 9% of flow. But during the summer, human use (primarily irrigation) is 70% of the total water available. And in August, water use is almost 80% of total water.

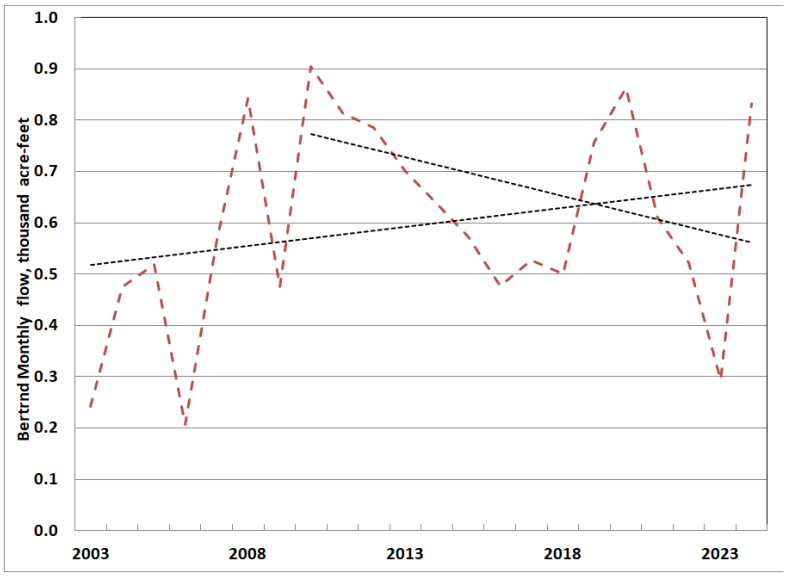

Fig. 5. Summer flows in Bertrand Creek.

INTERPRETATION

As expected, results for these three water bodies are quite different. In a sense, the mainstem at Nooksack represents, at least roughly, the entire watershed, both in terms of water supply and water demand. Fishtrap and Bertrand creeks, at the other end of the spectrum, represent small tributaries with substantial amounts of water use, primarily for agricultural irrigation.

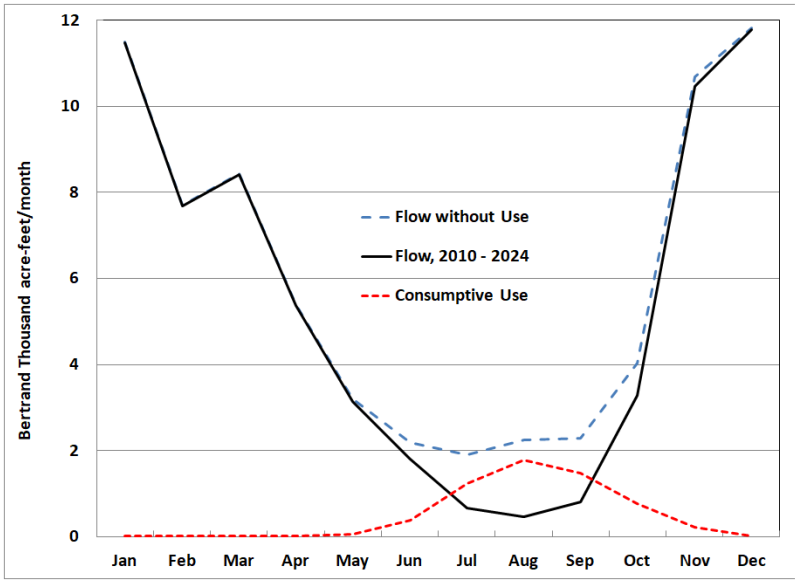

Fig. 6. Monthly flows in Bertrand Creek and estimated water use.

The amount of water flowing through Fishtrap, averaged over the year, is 2% of the Nooksack volume. During the three summer months, the Fishtrap volume is only 0.6% of the Nooksack volume. The comparable numbers for Bertrand Creek relative to the mainstem are 2.4% and 0.5%. Thus, Fishtrap and Bertrand flows are much more variable than are mainstem flows. Because of this larger seasonal variation in the two tributaries, the effects of water use on summer flows are much greater in the two creeks than in the mainstem; compare Figs. 4 and 6 with Fig. 2.

CONCLUSIONS

Based on these three locations, the relationship between streamflows and human water use vary dramatically throughout the Nooksack watershed. In the basins where farms predominate, the effects of water use on summer streamflows are substantial. In other basins, water use probably has only modest effects on instream flows (Fig. 7).

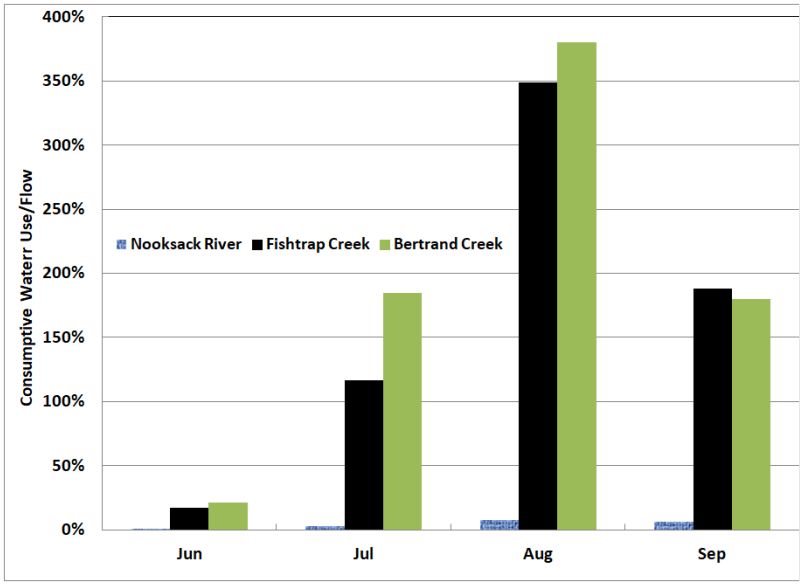

Fig. 7. Consumptive water use as a percentage of streamflow for three watersheds.

The results presented here should be replicated for several other sub-basins within the Nooksack watershed, both to verify the findings developed here and to better understand the relationships between water use and water supply. Such an analysis is important because:

- Climate change is dramatically affecting seasonal flows throughout the watershed.
- These declines are virtually certain to continue for the next few decades.
- Climate change is increasing the need for irrigation as summers become hotter and drier.
- Agricultural irrigation needs to become much more efficient; and society should encourage, require, and help farmers adopt modern water-use efficiency practices and technologies. This likely will require changes in state water law to encourage, rather than discourage, efficiency.
- The Nooksack adjudication should be informed by the relationships between available supplies and demands.

APPENDIX

Table 1 shows details for the results developed here.

Table 1. Summary of results, thousand acre feet/month

	Nooksack River @ Ferndale				Fishtrap Creek				Bertrand Creek			
	Flow, 2010-2024	Consumptive Water Use	Use/ Flow	Flow wo Use	Flow, 2010-2024	Consumptive Water Use	Use/ Flow	Flow wo Use	Flow, 2010-2024	Consumptive Water Use	Use/ Flow	Flow wo Use
Jan	338	0.45	0.1%	338	9.51	0.02	0%	9.54	11.48	0.02	0%	11.50
Feb	238	0.44	0.2%	239	6.79	0.02	0%	6.81	7.69	0.02	0%	7.71
Mar	244	0.45	0.2%	244	7.26	0.02	0%	7.28	8.41	0.02	0%	8.43
Apr	234	0.45	0.2%	234	5.03	0.02	0%	5.06	5.37	0.02	0%	5.39
May	292	0.65	0.2%	293	3.23	0.06	2%	3.29	3.14	0.06	2%	3.21
Jun	256	2.03	0.8%	258	2.02	0.35	18%	2.37	1.79	0.38	21%	2.25
Jul	180	5.64	3.1%	186	0.97	1.13	116%	2.10	0.67	1.23	184%	2.29
Aug	103	7.87	7.6%	111	0.47	1.63	348%	2.10	0.47	1.78	380%	3.29
Sep	103	6.49	6.3%	110	0.72	1.35	188%	2.07	0.82	1.47	180%	3.73
Oct	170	3.51	2.1%	174	2.29	0.70	30%	2.98	3.27	0.76	23%	5.03
Nov	327	1.30	0.4%	328	6.72	0.21	3%	6.93	10.45	0.23	2%	10.96
Dec	291	0.45	0.2%	291	8.22	0.02	0%	8.24	11.79	0.02	0%	11.81
Average/year	231	2.48	1.1%	234	4.44	0.5	10%	4.90	5.45	0.50	9%	6.32
Jul-Sept Ave	129	6.67	4.6%	136	0.72	1.4	191%	2.09	0.65	1.49	229%	3.10

Table 2 shows the estimates used of Whatcom County water use and the associated consumptive water use for the three basins examined here. Because irrigation dominates summer water use, when flows are lowest, I disaggregated the total between irrigation and non-irrigation water uses. Based on estimates from Ecology, I assumed that 85% of irrigation water use is consumptive and 10% of non-irrigation water use is consumptive.[10]

Table 2. Estimated consumptive water use (acre feet) for the Nooksack watershed

	Nooksack River				Fishtrap Creek			Bertrand Creek		
	Irrigation	IrrigAdj	Non-Irrig	Total	IrrigAdj	Non-irrig	Total	IrrigAdj	Non-irrig	Total
Jan	-	-	450	450	-	23	23	-	23	23
Feb	-	-	442	442	-	22	22	-	22	22
Mar	-	-	454	454	-	23	23	-	23	23
Apr	-	-	450	450	-	22	22	-	22	22
May	543	159	490	649	35	25	60	39	25	63
Jun	4,755	1,465	566	2,031	326	28	354	356	28	384
Jul	14,241	4,908	734	5,642	1,091	37	1,128	1,192	37	1,229
Aug	15,365	7,174	696	7,871	1,595	35	1,630	1,744	35	1,779
Sep	5,994	5,940	545	6,485	1,321	27	1,348	1,445	27	1,472
Oct	-	3,023	488	3,511	672	24	697	736	24	760
Nov	-	848	449	1,297	189	22	211	207	22	229
Dec	-	-	449	449	-	22	22	-	22	22
Total	40,898	23,517	6,214	29,731	5,230	311	5,540	5,718	311	6,029

[10] Ecology, GUID-1210, *Water Resources Program Guidance: Determining Irrigation Efficiency and Consumptive Use*, Oct. 11, 2005.

I assumed that the Fishtrap watershed contained 7,300 acres of irrigated farmland and used 10,700 acre-feet of water per year.[11] I also assumed that this basin accounted for 5% of the county's non-irrigation water use. For Bertrand Creek, I assumed 8,000 acres of irrigated farmland and 11,700 acre-feet of irrigation water.[12] Again, I assumed that this basin accounted for 5% of the county's non-irrigation water use. In both basins, these numbers imply an irrigation use of 1.46 acre-feet/acre.

LIMITATIONS

Interpreting the results of this analysis is limited by two major uncertainties. First, the present analysis treats groundwater and interactions between groundwater flows and surface waters in an approximate fashion.[13] I assume that the effects of groundwater withdrawals reduce streamflows by one-third in the month of withdrawal, one-third the following month, and the final one-third two months after withdrawal. I also assume that 85% of irrigation water use is from wells rather than directly from surface waters. And I assume an overall depletion rate of 50%, which means that half of the groundwater use does not affect streamflows. Additional analysis of the effects of groundwater withdrawals on streamflows is sorely needed.[14]

The second uncertainty concerns human water use. Although meter data exist for all the water utilities in Whatcom County, no entity has aggregated (or at least sampled) these sources to develop reliable estimates of actual water use. More important is the total lack of publicly available water-meter data for agricultural irrigation, which accounts for roughly 70% of total summer use.[15] (Data on rural homes with water drawn from wells are also not available.) The numbers developed here are based largely on the *Washington Irrigation Guide*, which is three to four decades old and out of date.[16] The water use numbers presented here are based on estimates for 2014.[17] The only study covering this topic sponsored by the WRIA 1 (Water Resource Inventory Area 1) Watershed Management Project did not cover the entire watershed and was published 12 years ago.[18]

As noted above, data limitations required us to make several assumptions and simplifications in this analysis. Thus, these findings and conclusions should be viewed as directional and not definitive.

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[11] RH2 Engineering, *Quantification of Agricultural Irrigation Water Use and Water Rights*, Dec. 2016. Also, E. Hirst, *Unpermitted Irrigation in Whatcom County*, Sept. 2017.

[12] See prior footnote. (The *Lower Nooksack Water Budget* from 2012 estimated 9,793 acres of irrigated farmland in the Fishtrap basin and 7,348 acres in the Bertrand basin.)

[13] The interaction between groundwater withdrawals and surface-water flows is complicated. Groundwater pumping causes streamflow depletion, the extent of which depends on the well's proximity to the stream, aquifer properties, and pumping rates.

[14] S.S. Papadopulos & Associates, Inc., *The Whatcom Groundwater Model (WGM): A Groundwater Model for the Lynden-Everson-Nooksack- Sumas Area of Whatcom County Steady State and Seasonal Average Transient Updates and Monthly Average Transient*, prepared for Whatcom County, March 1, 2024.

[15] E. Hirst, Analysis of Whatcom County Water Use, Jan. 2017.

[16] Washington Dept. of Ecology, *Updating the Washington Irrigation Guide*, Water Resources Program, Jan. 2012.

[17] See Hirst, footnote 15.

[18] C. Bandaragoda et al., Chapter 12 Existing Condition Water Budget Scenario, *Lower Nooksack Water Budget Project*, December 2012.