Comments on
Preliminary Draft Amendment to 173-501 WAC

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April 22, 2019

This memo provides comments on the Preliminary Draft *Amendment to Chapter 173-501 WAC, Instream Resources Protection Program - Nooksack Water Resource Inventory Area (WRIA) 1* and the accompanying *Rule Supporting Document*, both published by the Washington State Dept. of Ecology (Ecology) in April 2019. Although I am a member of the WRAI 1 Environmental Caucus, I write as an individual only. My comments focus on five issues:

- Water use efficiency (WUE): The opportunities and need for substantial increases in the effort aimed at improving WUE, especially for agricultural irrigation;
- Withdrawal limits: Lack of empirical basis for these limits.
- Water-meter data: At least a representative sample of new rural residential homes that use a permit-exempt well should have their water use metered, recorded, and analyzed. The proposed rule relies far too much on assumptions and estimates.
- Double-counting. Several of the projects planned to offset consumptive water use would likely have been implemented even without passage of ESSB 6091. Fish and other instream resources gain no benefits from projects that were already planned or underway.
- Climate change: Neither the proposed rule amendment nor the supporting document analyzes the likely effects of climate change on future water supply (decreasing) and demand (increasing). Does the 150% safety factor encompass climate change?

Water-Use Efficiency

Chapter 6 of the Supporting Document lists 13 projects that Ecology believes, in aggregate, will "achieve offsets and NEB." Even though a demand/supply imbalance can be met equally well by either increasing supply or decreasing demand, only one of the 13 projects includes WUE. And that project (46NG modified) has no details at all. Indeed, it is the only one of the 13 for which no estimates of offset amounts are provided.

This lack of information is both disappointing and surprising. Disappointing because WUE is likely a large and largely untapped resource in WRIA 1, saves water when it is most needed (summer), is likely very cost effective, is distributed throughout all nine subbasins, and requires no regulatory approvals for its implementation. Surprising because the environmental caucus distributed a paper to Ecology, Whatcom County Public Works, and the Planning Unit in July 2018 on "Water-Use Efficiency (WUE) Mitigation Options for WRIA 1 in Response to ESSB 6091. The paper, included here as Appendix A, offered several specific programmatic suggestions, references, and experts to consult with on the design and implementation of WUE programs. In addition, several local organizations can likely help Ecology in fashioning WUE

programs and projects, including the six agricultural watershed improvement districts and their coordinating body, the Ag Water Board; Whatcom Family Farmers; and Whatcom Conservation District.

I strongly urge Ecology to actively explore some of the options outlined in Appendix A (and elsewhere) for inclusion in the November 2019 proposed rule.

Withdrawal Limits

The RH2 analysis conducted last year derived an estimate of indoor water use of 154 gallons/day (gpd), based on Ecology's estimate of 60 gpd per capita and an average household size of 2.56 people. Nevertheless, Ecology chose as its standard a much higher number, 500 gpd. This 500 gpd number is also substantially greater than the 350 gpd standard governing permit-exempt wells on the Lummi Peninsula. Ecology should either revise downward its 500 gpd limit, or it should explain clearly why such a high number is appropriate.

In a similar fashion, Ecology should explain how it chose the 1/12-acre limit for outdoor water use. In addition, Ecology should explain how it converted acreage into gpd, e.g., using the Washington Irrigation Guide.

Water Meters

Based on the withdrawal limits noted above and an assumed 2,150 new rural homes to be built over the next 20 years, Ecology determined that the amount of water to be offset is 343 acre-feet/year. Using 154 gpd for indoor water use plus 1/12 acre for outdoor use yields an amount of water to be offset of 260 acre-feet/year. This amount was increased by a 150% safety facto to 390 acre-feet/year.

These acre-feet numbers are all based on many assumptions. Some of these assumptions could be replaced with data, real measurements of rural household water use. Appendix B is a paper I wrote last year on *How Much Water Do Whatcom Rural Homes Use?* For homes in rural Skagit County and Lynden, peak usage – based on water-meter data, not assumptions – in July or August is less than 500 gpd, which further calls into question Ecology's 500 gpd standard.

Equally important, standards, regardless of the level at which Ecology sets them, are irrelevant if they can't be monitored and enforced. Absent metering, I see no way to ensure compliance with the proposed standard [WAC 173-501-065(5)]. If Ecology disagrees with my assertion on the importance of metering at least a representative sample of rural homes, it should explain its approach to monitoring, compliance and enforcement in the November 2019 supporting document. The current supporting document states: "The department reserves the right to require metering and reporting of water use for domestic users, if more accurate water use data is needed for management of water resources in the area." What conditions would lead Ecology to require

metering, which and how many homes would be metered, who would be responsible for meter reading (and at what frequency), who would pay for data management, and who would be responsible for data management, analysis, and reporting? If metering is required for all new water users in the Dungeness water exchange (WRIA 18), why not in WRIA 1?

Double-Counting

Chapter 6 lists and explains the 13 projects that will be deployed to offset the amount of consumptive water use for these new rural homes that will use permit-exempt wells. Because some of these projects are already underway (e.g., 1, 2, and 19), it is inappropriate to include their water-production as offsets. While doing so may satisfy the legal requirements of the Streamflow Restoration Act, salmon and other instream resources gain no additional benefits from projects that would have been implemented in the absence of this legislation. As an example, when the Whatcom Land Trust decided to purchase the Skookum Creek property (Project 19), they surely were not expecting to encourage rural development. The same is true for Project 21.

Climate Change

Although the Supporting Document mentions climate change (page 10), the report provides no explicit attention to the growing and adverse effects of climate change. These effects include:

- Increases in summer air temperatures and decreases in summer rainfall, which imply greater water use for irrigation and outdoor domestic use, and
- Smaller glaciers, less snowpack, and less summer rain, which mean lower streamflows and higher stream temperatures during the critical summer months

Conclusions

Ecology accomplished a great deal in a short time in preparing the rule amendment and supporting document. Ecology staff deserves a great deal of credit for the comprehensiveness and clarity of the supporting document.

The time between now and November 2019, when the proposed rule will be published, gives Ecology the opportunity to strengthen the rule along the lines outlined here. In particular, developing details of a water-use efficiency program can increase instream flows where and when needed and do so in a way that is economically efficient and environmentally benign.

I urge Ecology staff to contact me (EricHirst@comcast.net) if there are any ways I can assist in this effort.

APPENDIX A:
WATER-USE EFFICIENCY (WUE) MITIGATION OPTIONS FOR WRIA 1 IN RESPONSE TO ESSB 6091

Environmental Caucus to WRIA 1 Planning Unit
July 9, 2018

INTRODUCTION

The environmental caucus believes that improving WUE represents an important and largely untapped class of options to increase streamflows in WRIA 1 watersheds. Generally, these options can cost-effectively and flexibly meet the requirements of ESSB 6091 to directly offset (water-for-water, in time, and in place) the consumptive water use from rural homes using permit-exempt wells. In particular, WUE measures and programs aimed at rural residential and agricultural irrigation water uses can directly address Ecology's requirements on the "amount, location and timing of benefits" needed to offset consumptive water use.[1]

The WUE programs suggested below meet many of the criteria in the June 28, 2018 Project Master List and Evaluation Matrix. Specifically, WUE has positive attributes in terms of

- Status (many of the technologies and programs are well established and far beyond the conceptual stage),
- Quantity, the amount of water saved to offset well water use is reasonably well known (and can be measured through water meters[2]),
- Seasonality, saves water during the summer months when it is most needed to protect and restore streamflows,
- Financial, is likely less expensive and more cost-effective ($/acre-foot) than many supply and storage projects,
- Flexible, because these WUE efforts can be ramped up or down as needed to match construction and water use for rural homes.

This note focuses on Residential and Agricultural water uses because those are the uses most common in the areas where rural exempt wells are located. That is, commercial and industrial users are more concentrated in the urban areas.

[1] Washington State Dept. of Ecology, *Interim Guidance for Determining Net Ecological Benefit*, Publication 18-11-009, June 2018 (page 5).

[2] Because no data exist on water use for rural homes in Whatcom County, it is essential to collect and manage such data for at least a representative sample of these homes. Data from Skagit and Kittitas counties show similarities in the monthly pattern of water use but stark differences in outdoor water use.

RESIDENTIAL

New construction standards: Require installation of high-efficiency water-use fixtures and equipment in all new rural homes (toilets, showerheads, front-loading washing machines, etc). These standards should also apply to irrigation systems. The standards would be set at the maximum cost-effective level.

Provide incentives to encourage WUE adoption in and outside existing rural homes: Offer financial assistance to help pay for more efficient residential water-using fixtures and equipment in existing rural homes, including lawn-watering and other outdoor water uses. Use the City of Bellingham program as a starting point.[3]

Purchase of indoor or indoor+outdoor water use package: Review Dungeness[4] and Kittitas[5] programs to mitigate rural residential water use. Develop mitigation packages to sell to rural homeowners: indoor-use only or indoor-plus-outdoor use. An outdoor option offers a way to limit outdoor water use and is much more palatable than a ban on outdoor water use in watersheds where summer flows are especially low. Include an enforcement clause (aerial photos, drone flights) in permits to ensure compliance with limits or prohibition on outdoor water use. The fees yielded by such a program (to replace the one set in ESSB 6091 of $500) would be more closely related to the actual cost of mitigation in Whatcom County and would provide money to pay for other mitigation projects in WRA 1.[6]

Information and education: Offer workshops to rural households on efficient outdoor water techniques and equipment. Conduct these programs with rural water associations and districts, building on their existing WUE programs. Although the benefits of such programs are hard to measure, they are very inexpensive and lay the groundwork for future actions to promote WUE.

AGRICULTURAL IRRIGATION

Because agricultural irrigation is, by far, the dominant water use during the summer, improving its efficiency could yield major savings, far more than needed to offset the consumptive water use from new rural homes.[7] [8]

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[3] Discuss with Riley Grant, City of Bellingham Natural Resources Division of Public Works, for additional ideas on WUE measures and program design. See also the Saving Water Partnership (Seattle and other local water utilities, https://www.savingwater.org/; talk with Phil Paschke (206-684-5883), Seattle Public Utilities).

[4] For more information on the Dungeness Water Exchange, contact Mike Gallagher, Section Manager in Ecology's SW Regional Office, 360-407-6305, MGAL461@ECY.WA.GOV.

[5] For more information on the Kittitas County program, contact Erin Moore, Kittitas County Environmental Health Dept., 509-962-7698, Erin.Moore@co.kittitas, wa.us.

[6] Any such program should ensure that low-income households are able to afford rural housing and use water to grow food.

[7] Talk with George Boggs and others at WCD to see what they are doing to improve agricultural WUE and help with those programs. Conduct similar conversations with the six WIDs and Whatcom Family Farmers.

[8] The Washington State Conservation Commission (WCC) runs an Irrigation Efficiencies Grant Program (IEP), funded by Ecology, to reduce agricultural water use and apply the saved water to instream flows for salmon

Improve irrigation scheduling efficiency: Washington State University developed software that farmers can use with a personal computer or smart phone to schedule use of their irrigation systems (when to turn on and how long to water) for the next seven days on the basis of various factors, such as soil type and depth; soil moisture; recent, current, and forecast weather conditions from a local weather station; type of crop, daily crop ET; and irrigation system efficiency.[9] "Improved irrigation scheduling … [could] decrease irrigation water use by 10-30% while resulting in equivalent or better crop yields and quality."

Focus on improved irrigation scheduling techniques, especially the one developed by Troy Peters and others at WSU – Prosser. Work with Troy Peters and Don McMoran, WSU Mt. Vernon, to implement such a program. Improved scheduling methods require no capital investment, although they may require some training for farmers in how best to use these systems.[10]

Improve irrigation system maintenance: In a similar fashion, develop, demonstrate and apply best-practices for maintaining irrigation equipment, including leak detection and repair.

Soil-moisture sensors: These sensors can help farmers decide when and how much to irrigate. Some soils permit application of large amounts of water at infrequent intervals, while other soils require smaller applications more frequently.[11]

CONCLUSION

As shown above, many options exist to improve water-use efficiency in WRIA 1. Developing and then adopting these options, along with cost-effective and environmentally benign supply and storage options, will result in a robust package of measures to best meet the requirements of ESSB 6091. The overall goal is to assess and rank individual efficiency and supply options to develop a portfolio of programs/projects that will best meet the ESSB 6091 requirements.

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recovery. The IEP projects deal with delivery systems (replace unlined ditches with liners or put water in pipes) and application systems (more efficient irrigation). As of 2015, 62 projects had been completed through the IEP, saving nearly 16,000 acre feet of water and 66 cubic feet per second of flow back into 23 tributaries.

[9] http://weather.wsu.edu/is/ISMManual.pdf, R. T. Peters, *irrigation scheduler mobile, User's Manual and Documentation*, Washington State University.

[10] A California study of the California Irrigation Management Information System "found that on average, the use of CIMIS increased yields by 8% and reduced water use by 13% [increasing productivity by 23%]." (H. Cooley et al., *Sustaining California Agriculture in an Uncertain Future*, Pacific Institute, July 2009)

[11] R. T. Peters, "Managing Irrigation Water on Different Soils in the Same Field," *Whatcom Ag Monthly*, 2(8), August 15, 2013.

SUGGESTED REFERENCES ON RESIDENTIAL AND AGRICULTURAL IRRIGATION WATER USE AND WATER-USE EFFICIENCY

General

http://www.allianceforwaterefficiency.org/resource-library/default.aspx
Alliance for Water Use Efficiency, Resources Library

https://www.epa.gov/sites/production/files/20162/documents/wc_best_practices_to_avoid_supply_expansion_2016_508.pdf
U.S. Environmental Protection Agency, *Best Practices to Consider When Evaluating Water Conservation and Efficiency as an Alternative for Water Supply Expansion*, EPA-810-B-16-005, Dec. 2016.

http://www.slcdocs.com/utilities/PDF%20Files/2014%20SLC%20Water%20Conservation%20Master%20Plan.pdf
2014 Salt Lake City Water Conservation Master Plan

Residential water use and efficiency references

http://www.waterrf.org/Pages/Projects.aspx?PID=4309
W.B. DeOreo et al, Residential End Uses of Water, Version 2: Executive Report, Water Research Foundation, April 2016.

W. B. DeOreo, "Some Key Results from Residential End Use of Water Study," Water Smart Innovations Conference, Las Vegas, NV, Oct. 2014.

W. B. DeOreo and M. Hayden, *Analysis of Water use Patterns in Multi-Family Residences*, for Irvine Ranch Water District, Oct. 2008.

Agricultural irrigation water use and efficiency references

https://www.ers.usda.gov/publications/pub-details/?pubid=44699
G.D. Schaible and M.P. Aillery, *Water Conservation in Irrigated Agriculture: Trends and Challenges in the Face of Emerging Demands*, U.S. Dept. of Agriculture, Sept. 2012.

https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/water/irrigation/irrigation-system-assessment-guide
British Columbia Agriculture Council, *Irrigation System Assessment Guide*, June 2005.

https://www.pacinst.org/reports/california_agriculture/final.pdf
H. Cooley et al., *Sustaining California Agriculture in an Uncertain Future*, Pacific Institute, July 2009.

http://css.wsu.edu/irrsoils/files/2016/01/FS086E-Managing-Irrigation-Water-on-Different-Soils.pdf
R. T. Peters, "Managing Irrigation Water on Different Soils in the Same Field," *Whatcom Ag Monthly*, 2(8), August 15, 2013.

http://pacinst.org/publication/california-farm-water-success-stories-2/
J. Christian-Smith and P. Gleick, *California Farm Water Success Stories*, Pacific Institute, March 2010.

http://weather.wsu.edu/is/ISMManual.pdf,
R. T. Peters, *irrigation scheduler mobile, User's Manual and Documentation*, Washington State University.

http://irrigation.wsu.edu/Content/Fact-Sheets/Drip-Irrigation-For-Ag-Producers.pdf
R. T. Peters, "Drip Irrigation for Agricultural Producers," Washington State University, Extension Service, undated.

https://www.researchgate.net/publication/271421378_Revising_Crop_Coefficient_for_Washington_Sate
T. Karimi, *Revising Crop Coefficients for Washington State*, MS Thesis, Dept. of Biological System Engineering, Washington State University, May 2012.

APPENDIX B:
HOW MUCH WATER DO WHATCOM RURAL HOMES USE?

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July 2018

In response to recent state legislation,[12] the Washington State Dept. of Ecology (Ecology), Whatcom County Public Works, and others in Water Resource inventory Area 1 (WRIA 1) are conducting a study of mitigation options. These options are intended to offset the consumptive water use for all of the homes constructed over the next 20 years (from January 2018) that draw water from permit-exempt wells.

Because these homes do not have water meters, no data currently exist on the amounts and timing of their water use in Whatcom County. Thus, assessing mitigation options requires assumptions on how much water these homes will use. Further, we need to identify separate amounts for indoor and outdoor uses because the consumptive losses[13] are so different for the two sets of uses. According to Ecology,[14] about 90% of indoor water use is returned to the local groundwater system (although with some delay and changes in water quality) via the home's septic system. Outdoor water use, however, is primarily consumptive, with about 80% lost to evaporation and transpiration. Calculating water use requires estimates on the number of people per household, the amount of land that is irrigated, the types of crops grown, and the amount of water used for irrigation.

This note focuses on outdoor/summer water use because of its primarily consumptive nature and because the summer months (July through September) are those with the lowest streamflows, which adversely affect salmon and other wildlife. I offer three sets of data that might serve as useful proxies for rural residential water use in Whatcom County until such time as we begin to meter these homes:

- 18 homes in Skagit County, with data on each home for 20112 and 2013[15]
- 2,613 single-family homes in Lynden that did not have a change in occupancy during the 3-year period from 2014 through 2016.[16]

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[12] Washington State Legislature, *An act relating to ensuring that water is available to support development*, Engrossed Substitute Senate Bill 6091, Jan. 19, 2018.

[13] Water use can be divided into two parts, consumptive and return flow. Consumptive water is that portion of the water used that is not returned to the system. For example, most of the water used for irrigation is lost to evaporation and transpiration. Return flow is that portion of the water used that is returned to the system.

[14] Ecology, *ESSB 6091 – Streamflow Restoration Recommendations for Water Use Estimates*, April 5, 2018. Ecology states that "consumptive water use is considered water that is evaporated, transpired, consumed by humans, or otherwise removed from an immediate water environment due to the use of permit-exempt domestic wells."

[15] Golder Associates, *Skagit County Exempt Well Metering Program – 2012-203*, Technical Memorandum, March 27, 2014.

[16] E. Hirst, *Improving Water-Use Efficiency: Focus on the Outliers*, July 2017.

- 21 homes in Kittitas County that participate in its Water Bank Mitigation & Metering Program for two years, from 2016 to 2018.[17]

Another possible source of relevant data, not explored here, is the small water associations serving rural homes in Whatcom County. I also obtained data from Ecology on rural homes that use water from wells on the Lummi Peninsula and in the Dungeness watershed. Unfortunately, these data were of such poor quality that I could not analyze them and draw any conclusions about actual water use in either location; see Appendix for details.

TOTAL WATER USE

Figure 1 shows month-to-month water use per household for Skagit and Kittitas counties and for Lynden. Results are qualitatively similar in that summer water use, especially in July and August, greatly exceed winter use.

Although the Skagit and Lynden results are similar, the Kittitas homes use much less water in the summer. This is likely because the 21 Kittitas homes all signed up for the indoor-only water use mitigation package.[18]

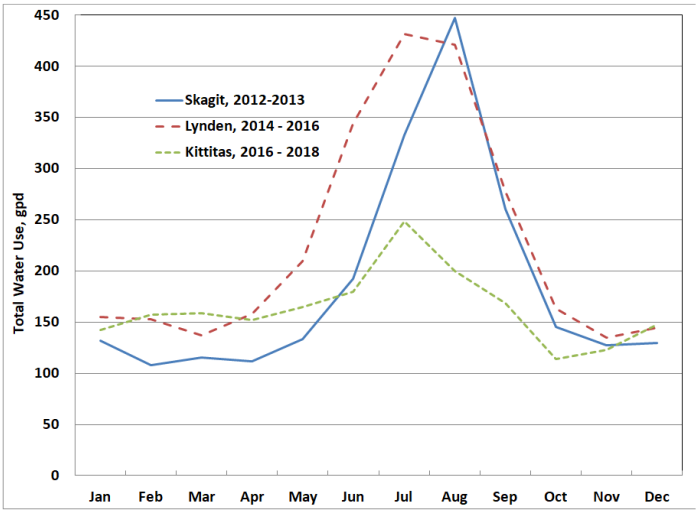

Fig. 1. Total water use for rural homes in Skagit and Kittitas counties and in Lynden.

The annual averages are 187 gallons/day (gpd) for Skagit, 228 gpd for Lynden, and 184 gpd for Kittitas. Peak monthly use is about 450 gallons per day (gpd) for Skagit and Lynden and 250 gpd for Kittitas.

OUTDOOR WATER USE[19]

Figure 2 compares these data sets for outdoor water use. The Skagit homes use 25% more water for outdoor purposes than do the Lynden homes. Averaged over July through September, the Skagit homes used 224 gpd, compared with 151 gpd for Lynden. The Kittitas homes, probably

[17] Kittitas County Public Health Department, *Water Bank Mitigation & Metering Program Policy & Procedures*, undated. See also https://www.co.kittitas.wa.us/health/services/water-banking-building-permits.aspx

[18] The number of homes that signed up for the indoor+outdoor package was too small and had participated in the program for too short a time to allow for meaningful analysis.

[19] I defined indoor water use as the average of the monthly values of water use for the months of January through May plus November and December. Outdoor water use is then the difference between total and indoor water use for each month.

because they committed to indoor-use only, use much less water for outdoor purposes, an average of 61 gpd over the three summer months.

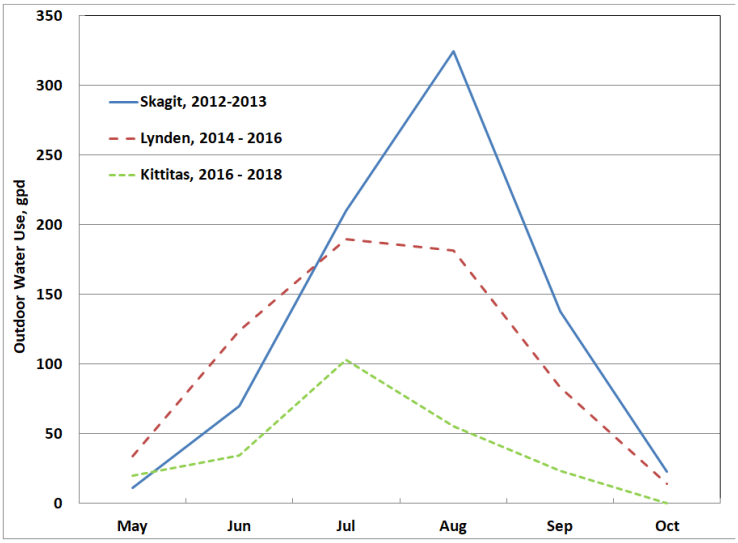

Fig. 2. Monthly outdoor water use for rural homes in Skagit and Kittitas counties and in Lynden.

Lacking data to explain differences between the Skagit and Lynden homes, I speculate that the rural homes are on larger parcels of land and, therefore, have bigger lawns and gardens that they irrigate. Also, Lynden residents pay water bills every month, and the rate schedule charges more for greater water use (an inclining-block-rate structure). Rural residents face no explicit water bills; their water operating costs are hidden in their electricity bills. Thus, Lynden households face explicit economic incentives to be efficient in their water use that rural residents do not.

Note that Skagit water use peaks in August, while Lynden and Kittitas water use peaks in July. Peak summer use ranges from 100 gpd for Kittitas to over 300 gpd for Skagit.

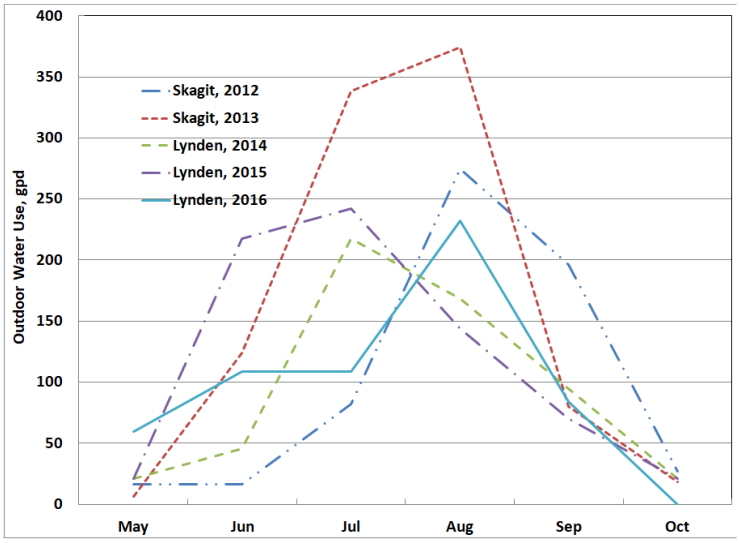

Fig. 3. Monthly outdoor water use by year for Skagit and Lvnden homes.

Figure 3 disaggregates these data to highlight differences from year to year. Skagit water use in 2013 was 43% higher than in 2012. And Lynden water use in 2015 was 7% higher than in 2016 and 13% higher in 2014 than in 2016. (Insufficient data were available for the Kittitas homes to permit this type of comparison.)

Ecology, in its guidance on estimating indoor and outdoor water use gives a sample calculation for outdoor water use for a "hypothetical pasture/turf grass example."[20] Figure 4 shows that the shape of the Ecology curve is very close to that for the 18 Skagit homes. I don't know whether

[20] Ecology, *ESSB 6091 – Streamflow Restoration Recommendations for Water Use Estimates*, April 5, 2018.

this close correspondence means (1) Ecology's approach is validated by real-world data, (2) the data from Skagit County represent rural homes outside the county, or something else.

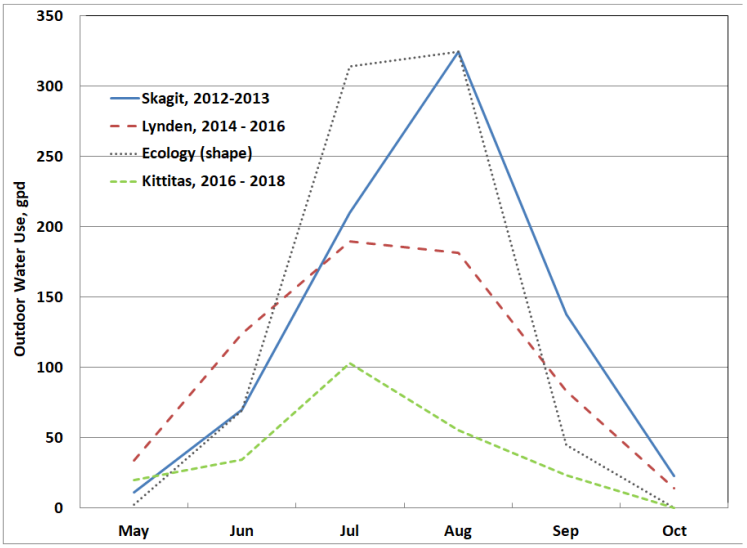

Fig. 4. Comparison of monthly outdoor water use shapes.

CONCLUSION

The current effort to update the 2005 WRIA 1 Watershed Management Plan should include a project to meter, record, validate, analyze and report data on a representative sample of residential rural wells in Whatcom County. The current choices for calculating how much water these homes use are all poor. Either we make several assumptions, none of which can be validated with data, or we rely on very small samples from other locations in Washington. Table 1, which summarizes the results presented here, shows wide variations in indoor and outdoor water use.

In the interim, the data on 18 rural homes in Skagit County are likely the best proxy for rural home water use in Whatcom County.

Table 1. Comparison of data and estimates on water use by rural homes, gallons per day

				Outdoor peak month	
	Total	Indoor	Outdoor	Usage	Month
Skagit	187	119	68	325	August
Lynden	228	174	54	190	July
Kittitas	163	145	34	103	July

These results suggest that we need to consider two key factors in determining the scope and scale of mitigation options:

- Size of the parcel and the associated types of landscaping, yards and gardens, and
- Year-to-year variations in summer air temperatures and rainfall. A related factor is the effects of climate change, with future summers almost certain to be hotter and dryer, which will increase irrigation water use.

APPENDIX: OTHER WATER-METER DATA SOURCES

I identified two other sources of data that might be relevant to rural household water use in Whatcom County: Lummi Peninsula and Dungeness. Unfortunately, after considerable work with these data, I concluded that their quality was so poor that analysis was not possible. The following discussion identifies data-quality issues to address when Whatcom County begins to collect and manage data on water use from rural residential wells.

In late 2016, I asked Ecology for water-meter data for homes on the Lummi Peninsula that were part of a settlement agreement; the settlement required these homes to use no more than 350 gpd, calculated as an annual average. Although these meters were read using an AMR system, Ecology was unable to send me the data in electronic form. Instead, I received a pdf file with 84 pages, each one containing meter readings for a particular month (from November 2010 through November 2016) for each of 77 homes.

I then entered these data into a workbook and began analysis. I immediately noticed several problems and anomalies:

- I dropped eight homes because the readings were all missing or zero.
- Ecology provided data with two different forms for different months, called "Upload Reports" and "Meter Reading Worksheet," which complicated data interpretation.
- Sometimes, the meter-reading dates were inconsistent on different parts of the forms, making it difficult to determine the exact time periods for each meter read.
- Many of the meter readings showed negative, missing, or zero values for consumption. I was not able to determine whether, for example, a negative value was caused by a change in meter or an error in meter reading. I could not tell whether a zero reading actually reflected a lack of occupancy for that month (which seemed unlikely given the large number of zero readings) or was an error.

At this point, I stopped analysis because it was not possible to apply normal data-quality controls and still obtain a representative set of data.

Earlier this year, I obtained data from Ecology on meter data for 131 homes in the Dungeness basin (WRIA 18) covering the period from October 2014 through December 2017, just over three years. Although the database nominally included 131 homes, non-missing and non-zero meter readings were available for no more than 98 homes, with an average of only 38 homes over this 26-month period.[21]

These meters were read infrequently, only eight times, which yields at most seven data points for a household's water use. Because very few households were enrolled in the program in 2014 and well into 2017, the average home had only two data points. Looking only at the last three

[21] Almost 4% of the calculated water use values were negative, an impossibility.

readings, which covered water use from May to December 2017, about 60 homes were included in the database.[22]

Because of the small number of homes for which data were available and because meters were read infrequently, it is very hard to interpret the results. For example, the penultimate reading covered July – September 2017, which roughly covers the summer, when water use is high. The last reading covered September – December 2017, which excludes any summer months. Not surprisingly, average use during the former period was 141 gpd, compared with 101 gpd during the latter period.

As another example of the complexity of interpreting these results, data for 37% of the homes showed an average consumption of 25 gpd or less, much lower than the norm of 60 gpd per person.[23] At the other end of the spectrum, 5% of the homes used more than 500 gpd, which also seems very unlikely. Including these outliers could skew results of any statistical analysis.

These changes in time periods covered, seasonality, inclusion/exclusion of various homes, and data quality make it, in my view, impossible to draw conclusions from these data.

[22] I am puzzled that Ecology, even if it read meters infrequently, did not upload the detailed data that these Neptune R900 units could store: "96 days of hourly data logging capability."
https://www.neptunetg.com/products/endpointsmius/r900/

[23] Some of these low-usage accounts might be second homes, occupied only occasionally.