ESSB 6091 – Streamflow Restoration
Recommendations for Water Use Estimates

This document provides the Department of Ecology's recommendations for estimating water use by permit-exempt domestic wells in compliance with the provisions in Engrossed Substitute Senate Bill (ESSB) 6091. The methods described are not rigid requirements, and planning units and watershed restoration and enhancement committees can modify these methods based on credible, location-specific information with Ecology concurrence. Ultimately, restoration plans and plan updates will be judged by two tests: that the total quantity of water consumed by permit-exempt domestic wells is offset, and that a "net ecological benefit" is provided over the subsequent 20 years. Any methods used must be sufficient to allow Ecology to make that determination.

General approach

Permit-exempt domestic wells may be used to supply houses, and in some cases other Equivalent Residential Units (ERUs) such as small apartments. For the purposes of this document, the terms "house" or "home" refer to any permit-exempt domestic groundwater use, including other ERUs.

Interpretation of Law Requirements

Sections 202 and 203 of ESSB 6091 contain several provisions regarding how watershed restoration and enhancement plans and updated watershed plans are to offset or account for projected water use.
Specifically, sections 202(4)(b) and 203 (3)(b) state,

> *At a minimum, the [watershed] plan must include those actions that the planning units determine to be necessary to offset potential impacts to instream flows associated with permit- exempt domestic water use. The highest priority recommendations must include replacing the quantity of consumptive water use during the same time as the impact and in the same basin or tributary. Lower priority projects include projects not in the same basin or tributary and projects that replace consumptive water supply impacts only during critical flow periods.*

Timeframe: To evaluate and offset potential consumptive impacts from permit-exempt domestic wells, a timeframe over which new domestic use will be considered must be designated. Since a "subsequent twenty years" is referenced throughout other sections of ESSB 6091 (such as sections 202(4)(c), 203 (3)(c), 203(3)(d), and 203(3)(e)), Ecology interprets the timeframe for 202(4)(b) and 203 (3)(b) to be the next twenty years.

Scope of "water use": Ecology interprets all projected water use referenced in sections 202(4)(c), 203(3)(c), 203(3)(d), and 203(3)(e) to refer to only consumptive permit-exempt domestic groundwater water use (as opposed to water use associated with municipalities, for example). Ecology's Initial Policy Interpretations publication provides additional explanation.

Consumptive use: Water Resources Program Policy 1020 (1991) states, "Consumptive water use causes diminishment of the source at the point of appropriation," and that, "Diminishment is defined as to make smaller or less in quantity, quality, rate of flow, or availability." This guidance document is focused on estimating only quantity diminishment, so for the purposes described here, 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.

Subbasins: ESSB 6091 is written in the context of Water Resources Inventory Area (WRIA)-wide mitigation, so Ecology interprets the words "same basin or tributary" to refer to subareas or subbasins as opposed to entire WRIAs. For the purposes of this document, the term "subbasin" is equivalent to the words "same basin or tributary" as used in sections 202(4)(b) and 203 (3)(b). Planning groups must delineate subbasins within WRIAs, and these subbasins must be suitably sized to allow meaningful determinations of whether mitigation is in-time and in the same subbasin in the context of highest priority and lower priority projects, without being so small that they are unwieldly (e.g. a WRIA might be divided into eight subbasins). In some instances, subbasins may not correspond exactly with hydrologic basin delineations (i.e. watershed divides).

Estimating the Number of Future Permit-Exempt Domestic Wells

Plans and plan updates must describe the consumptive use of permit-exempt domestic wells over the next 20 years. There are numerous ways to make such predictions for WRIAs or subbasins. The first two methods described below rely on building permit data and population data, and both of these tend to provide fairly robust results. Ideally, both of these methods will be applied or some hybrid of the two, and the results compared. The third method mentioned is an analysis of Ecology's well log data, however, results relying on those data tend to be less reliable.

One method for predicting future permit-exempt domestic wells involves conducting a Geographic Information System (GIS) analysis of county building permits, zoning, and parcel information. Once these data have been segregated into WRIAs or subbasins, single-family building permit data can be evaluated to determine the number of building permits issued over some previous time period (e.g. the past 10 years). Those results can then be used to project permit-exempt domestic wells over the subsequent 20- year period, based on assumptions regarding how many of those building permits translate into permit- exempt domestic wells, zoning restrictions, information on undeveloped parcels, etc.

Another method of predicting future permit-exempt domestic wells relies on population data. The Washington State Office of Financial Management (OFM) website provides estimates of past and current populations by WRIA, and projected future household populations on a county basis. One way to predict future populations is to look at populations for two different years (e.g. 2007 and 2017), then use that rate of increase to predict future populations. Upon request, OFM can also prepare 2000-2017 small area estimates. Therefore planning groups can provide OFM GIS shapefiles for their subbasins, then a similar method can be used to predict future populations for individual subbasins. An alternate method of using the OFM data is to use current populations for a given subbasin or WRIA as a base, then increase that number based on county population projections. This latter method requires subjectivity, however, since all of the WRIAs span two or more counties, and this method requires looking at projections for multiple counties, then inferring a reasonable assumptions for each subbasin or WRIA.

- OFM population by WRIA 2000 through 2017 is available at: https://www.ofm.wa.gov/washington-data-research/population-demographics/population-estimates/small-area-estimates-program
- OFM projected growth rate by county 2010–2050 by one-year intervals is available at: https://ofm.wa.gov/sites/default/files/public/dataresearch/pop/GMA/projections17/gma_2017_1yr_2050.xlsx

Once future WRIA populations have been estimated, those populations that will be served by community water systems and municipalities must be removed. This can be done relying on available information on the distribution/growth rate patterns of populations served by water systems. Finally, future populations that will be served by permit-exempt domestic wells can be divided by the average number of people per household currently (U.S. Census Bureau Quick Facts) to estimate the number of future permit-exempt domestic wells.

A third potential method relies on spatial data for well reports (logs) available from Ecology (https://ecology.wa.gov/Research-Data/Data-resources/Geographic-Information-Systems-GIS/GIS-data). Wells in this data set with a "W" in the Well type field correspond with water supply wells. Those data can be analyzed using GIS to determine the number of recorded water supply wells for two past years (e.g. 2007 and 2017), then those data can be used to predict the rate of well increase into the future. However, the reliability of estimates for future wells using this method will likely be less reliable.

Total Water Use versus Consumptive Water Use

Estimates of water use by future permit-exempt domestic wells must account for the portion of water that is consumptively used. To do this, water use estimates should be divided into indoor and outdoor water use, then those estimates adjusted to account the portion of water that will return to the hydrologic system.

In general, most houses on permit-exempt domestic wells are connected to individual septic systems. For those houses, indoor water that is discharged via septic system mostly returns to the groundwater system, and the water used outdoors is mainly lost to evapotranspiration. The percentage of water consumed (lost to the atmosphere) during these processes is a function of climate, soil type, aspect, etc., and varies across the state.

A reasonable assumption for much of Washington is that about 10 percent of indoor domestic water use is consumed, and about 80 percent of outdoor domestic water use is consumed (Culhane and Nazy, 2015). A consumptive use rate of 10 percent for indoor domestic use is in keeping with recent groundwater models constructed by the U.S. Geological Survey (USGS) for the Kitsap peninsula (Frans and Olsen, 2016) and the Chamokane Creek basin (Ely and Kahle, 2012). However, the USGS has used various percentages for outdoor consumptive use. For the Kitsap peninsula model, the consumptive use rate for outdoor use was assumed to be 90 percent. By contrast, USGS reports for the Chambers-Clover watershed in Pierce County (Johnson et al., 2011) and the Spokane Valley-Rathdrum Prairie Aquifer (Hsieh et al., 2007) assumed landscape irrigation efficiency of 60 percent.

If houses are connected to sewer systems that discharge water outside of or near the mouth of a watershed, it can be assumed that 100 percent of the indoor water use consumptive.

Watershed planning groups can use assumptions other than 10 percent and 80 percent for indoor and outdoor water consumption, respectively, if justification is provided. However, ultimately, Ecology will need to use these results to determine whether the total quantity of water consumed by permit-exempt domestic wells will be matched, and whether a "net ecological benefit" will be provided over the next 20 years. Therefore, substitutions of different percentages need to have Ecology concurrence.

Performing Consumptive Water Use Analyses

ESSB 6091 requires offsetting the quantity of water consumptively used by future domestic permit-exempt wells during the subsequent 20-year period somewhere within the WRIA. Within this requirement, the law establishes higher and lower priority projects to provide this offset. The discussion below begins with basin-wide or lower priority projects analyses, since the method described constitutes the base level of analysis. Next, consumptive water use analyses for higher priority projects are discussed, and more information is provided regarding basin-wide calculations.

In reality, there does not need to be a strict dichotomy between lower and higher priority projects as described in 202(4)(b) and 203 (3)(b), and some projects may fall in between. For example, acquisition of a water right that addresses consumption in the same subbasin may be deemed a "medium" priority, since while it provides offsets in the same subbasin, it also mitigates for impacts only during critical times. In that instance, analyses as described for both low priority and high priority projects would be necessary in order for Ecology to have adequate information to determine whether there will be a "net ecological benefit."

When developing or updating watershed plans, all planning groups will have the option of recommending limits on the numbers of wells or the amounts of water those wells can pump within a specific subbasin or entire WRIA, in order to reduce the amount of water use impacts that must be offset. As such, it may be helpful for planning units to generate more than one estimate of consumptive water use, using different sets of assumptions for outdoor water use, so that this information will be available when developing watershed plan alternatives.

1. Basin-wide and Lower Priority Project Analyses – Sections 202(4)(b) and 203 (3)(b)

The law requires that somewhere within the WRIA watershed plans offset the WRIA-wide annual consumptive domestic water supply uses that will occur over the subsequent 20-year period. The law also requires that lower priority projects—those that do not occur in the same basin or tributary—replace consumptive domestic water supply uses somewhere within the WRIA during critical flow periods over the subsequent 20-year period. To evaluate whether these requirements will be met, it is necessary to estimate the total annual consumptive quantity of future permit-exempt domestic withdrawals. These annual quantities can be estimated by looking at the anticipated increases in population and/or permit-exempt domestic wells, then making a series of assumptions regarding indoor and outdoor consumptive water use. The following describes steps to produce those estimates.

A. Consumption due to Indoor Water Use

To estimate the impacts of indoor water use, the population to be served by future permit-exempt domestic wells can be multiplied by assumed water use. A 2016 study by the Water Research Foundation (DeOreo, et al., 2016) determined an average per capita water use of 59 gallons per day (gpd) in homes provided municipal water in 23 areas across the U.S. and Canada. This result is based on actual flow monitoring and survey responses from 737 homes. The 59 gpd average is down 15.4 percent from results found during a 1999 American Water Works Association Research Foundation study (Mayer and DeOreo, 1999). Some homes supplied by Tacoma Water were monitored for the 2016 report, producing an average 51 gpd per capita indoor water use. Bearing in mind that homes supplied municipal water are more likely to be fitted with water saving appliances, an assumption of 60 gpd per capita seems reasonable when estimating water use for permit exempt wells.

To produce a result in acre feet per year (AF/YR), estimated daily water use can be multiplied by 365 days per year, then converted to units of AF/YR, then multiplied by an assumed amount of water use that is consumptive. Different assumptions apply to homes connected to sewer systems versus those on septic systems. If homes are connected to sewer systems that discharge water outside of or near the mouth of a watershed, the assumption is that indoor water use is 100 percent consumptive. If homes are connected to septic systems, the estimated total annual water use for permit-exempt domestic wells can be multiplied by an assumed consumptive use factor, such as 10 percent, since most of this water will return to the ground via septic systems.

B. Consumption due to Outdoor Water Use

Under RCW 90.44.050, there is a maximum limit of one-half acre for outdoor watering associated with permit-exempt domestic wells. However, the average outdoor water use area in any given area may be less. One method of estimating future outdoor water use is based on an estimate of the average outdoor watering area for existing homes on permit-exempt domestic wells. Such analyses can be conducted using GIS and satellite imagery, and can be rigorous or as simple as scanning images to get a qualitative sense of the outdoor lawn/garden areas associated with existing homes. If planning units or watershed restoration and enhancement committees choose not to perform this level of analysis, an alternative would be to simply assume one-half acre of outdoor watering area associated with future permit-exempt domestic wells.

Once an outdoor water use area has been selected, future permit-exempt domestic outdoor water use can be estimated using an assumed crop type (e.g. pasture/turf grass) and relying on crop use estimates for nearby station(s), such as those available in Appendix A in the Washington Irrigation Guide (WAIG) (U.S. Department of Agriculture, 1997). This number can then be multiplied by an assumed outdoor watering area, as well as factors to account for both irrigation inefficiency and the amount of water that is unused and returns to the ground.

Use of Other Data

In some instances, additional location-specific information may exist to supplement or replace portions of the method. One example would be actual water use data for small- to medium-sized water systems within a county. Depending on the nature and distribution of such data, extrapolations might be used to either verify or modify the above estimates. However, one caution is that water system estimates may be low if users pay fees that include built in incentives to conserve water.

In all instances, any significant variances from the above methods need to be well documented with reasons why the changes are justified.

Method Example

Assuming the methods described in 1A and 1B are used, an estimate of the consumptive water use for future permit-exempt domestic withdrawals might look like the following:

Household Consumptive Indoor Water Use (HCIWU):

Depending on the methods used to predict the number of future permit-exempt domestic wells (see page 2), the population using wells may already have been determined. If an estimate of the number of future permit-exempt domestic wells relied on county building permit data or Ecology's water-well report spatial data, that number of wells can be multiplied by an average number of people per

household to estimate increased population. Estimates of average household numbers are available from the U.S. Census Bureau or OFM, however, some inference will be required to convert these from a county to a WRIA basis.

For the example here, it will be assumed that there are 2.5 people per household. Given that assumption, and assuming per capita water use of 60 gpd and that only 10 percent of indoor water use is consumptive, an example of a consumptive indoor water use per house calculation in acre-feet per year (AF/YR) would be:

HCIWU = 60 gpd X 2.5 people per house X 365 days X 0.00000307 AF/gal. X 10% cons. use = 0.017 AF/YR

Household Consumptive Outdoor Water Use (HCOWU):

To estimate consumptive outdoor water use per household, domestic lawn/garden irrigation requirements can be estimated using information for a nearby station found in Appendix A of the Washington Irrigation Guide (WAIG) (U.S. Department of Agriculture, 1997). For a hypothetical pasture/turf grass example, the WAIG irrigation requirements (inches) might look something like:

	May	June	July	August	September	Total
Irrigation requirements (inches)	0.63	2.72	4.11	2.75	0.9	11.11

The irrigation requirement can then be divided by 12 to convert from inches to feet, then multiplied by an assumed outdoor watering area, which for this example is 0.4 acre:

Irrigation Requirements (in.) = 11.11 inches/12 inches per feet X 0.4 acres = 0.37 AF/YR

When consumptive water use for irrigation is calculated in accordance with Water Resources Program Guidance 1210, it includes a step to account for water lost during the water application process (e.g. water sprayed on a sidewalk instead of a lawn). So for this example if the efficiency for a residential pop-up sprinkler system is assumed at 75 percent, the required water amount would be:

0.37 acre-feet ÷ 75% application efficiency = 0.49 acre-feet

The method in Guidance 1210 then subtracts out the amount of water that is not consumed and returns to groundwater or the surface water system. So for this example assuming the consumptive loss associated with outdoor water use is 80 percent, the estimated total consumptive outdoor water use per house during the irrigation season would be:

0.49 acre-feet x 80% consumed (20% return flow) = 0.39 acre-feet

So under this scenario Household Consumptive Outdoor Water Use (HCOWU) equals 0.39 acre-feet.

Basin-wide Household Consumptive Water Use (BHCWU):

Consumptive water use by future permit-exempt domestic wells for a WRIA or subbasin can then be estimated by:

BHCWU = number of houses served by permit-exempt domestic wells X (HCIWU + HCOWU)

2. Highest Priority Projects – Sections 202(4)(b) and 203 (3)(b)

ESSB 6091 states that the highest priority recommendations must replace the estimated 20-year quantity of consumptive domestic water use in-time and in the same basin or tributary. Estimating the timing of groundwater impacts on streams can be complicated due to potential lags between when wells are pumped and when pumping impacts propagate to rivers or streams. If a shallow well pumps an unconfined aquifer directly adjacent to a stream, the effects of pumping can be almost instantaneous. However, if a well pumps a confined aquifer some distance from a stream, smaller effects can occur down gradient and over much longer periods.

In order to analyze timing of the effects of groundwater pumping, the hydrogeology and locations of wells must be taken into account. In addition, the timing and magnitude of pumping may need consideration. However, unless a well is completed in bank storage right next to a stream, pumping groundwater at 50 gallons per minute (gpm) for one hour per day (say, for lawn watering) may have approximately the same effect as pumping a well at 5 gpm for 10 hours per day.

In all situations, the place to start the analysis will be to construct a conceptual groundwater model that factors in the hydrogeology, geographic distribution, and depths of the wells. In water resources terms, conceptual groundwater models generally include spatial delineations of recharge and discharge areas, identification of pathways from unsaturated zones through saturated zones to groundwater receptors, and analyses and estimates of time scales of flow and effects of groundwater pumping. A conceptual groundwater model can provide a basic framework with which to evaluate different types of groundwater pumping.

In some instances, the next level of analysis could involve applying a simple analytical model such as USGS STRMDEPL08 (Reeves, 2008), which is capable of estimating streamflow depletion by a nearby pumping well. However, since analytical models cannot deal with many spatially distributed wells simultaneously, at best the results of a limited number of analytical model runs could be used to refine a the conceptual model. If a numerical groundwater model (e.g. USGS MODFLOW) is available, this can be used to provide much more reliable estimates. However, such models are expensive and require significant time to develop and use.

In all instances where high priority projects are being considered, sufficient technical bases must be provided to evaluate whether the projects will replace consumptive water use during the same time and within the same basin or tributary as groundwater pumping impacts. In addition to the analyses described in this section, analyses associated with highest priority projects also need to include the same sorts of consumptive water use estimates as described in Item 1 above.

3. WRIA-Wide Calculations – Sections 202(4)(c), 203(3)(c), 203(3)(d), and 203(3)(e)

Ecology interprets all projected water use referenced in sections 202(4)(c), 203(3)(c), 203(3)(d), and 203(3)(e), to refer to only consumptive permit-exempt domestic groundwater water use (as opposed to water use associated with municipalities, for example). Ecology's Initial Policy Interpretations document provides additional explanation. To make determinations prescribed in the law that meet these requirements, the total consumptive permit-exempt domestic groundwater use for the entire WRIA must be projected over the subsequent 20-year period.

References

Culhane, T., and Nazy, D., 2015. Permit-Exempt Domestic Well Use in Washington State. Washington State Department of Ecology, Water Resources Program, Publication No. 15-11-006. https://fortress.wa.gov/ecy/publications/SummaryPages/1511006.html

DeOreo, et al., 2016. Residential End Uses of Water, Version 2. Water Research Foundation, Report #4309b. Executive summary available at: http://www.circleofblue.org/wp-content/uploads/2016/04/WRF_REU2016.pdf

Frans, L.M., and T.D. Olsen, 2016. Numerical Simulation of the Groundwater-Flow System of the Kitsap Peninsula, West-Central Washington. U.S. Geological Survey, Scientific Investigations Report 2016–5052, p. 63. https://pubs.usgs.gov/sir/2016/5052/sir20165052.pdf

Hsieh, P.A., et al., 2007. Ground-Water Flow Model for the Spokane Valley-Rathdrum Prairie Aquifer, Spokane County, Washington, and Bonner and Kootenai Counties, Idaho. U.S. Geological Survey Scientific Investigations Report 2007–5044, p. 78. https://pubs.usgs.gov/sir/2007/5044/pdf/sir20075044.pdf

Johnson, K.H., Savoca, M.E., and Clothier, B., 2011 Numerical Simulation of the Groundwater-Flow System in the Chambers–Clover Creek Watershed and Vicinity, Pierce County, Washington U.S. Geological Survey, Scientific Investigations Report 2011–5086, p. 108. https://pubs.usgs.gov/sir/2011/5086/pdf/sir20115086.pdf

Mayer, P.W. and DeOreo, W.B. 1999. Residential end uses of water. American Water Works Association Research Foundation. p. 310.

Natural Resource Conservation Service, 1997. Washington Irrigation Guide (WAIG). U.S. Department of Agriculture. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/wa/technical/engineering/?cid=nrcs144p2_036314

Reeves, H.W., 2008, STRMDEPL08—An Extended Version of STRMDEPL with Additional Analytical Solutions to Calculate Streamflow Depletion by Nearby Pumping Wells: U.S. Geological Survey Open-File Report 2008–1166, p. 22. https://mi.water.usgs.gov/software/groundwater/strmdepl08/

Department of Ecology, 1991. Water Resources Program, Guidance 1020, Consumptive and Nonconsumptive Water Use. Washington State, Department of Ecology, p. 3. https://fortress.wa.gov/ecy/wrx/wrx/fsvr/ecylcyfsvrxfile/WaterRights/wrwebpdf/pol1020.pdf

Department of Ecology, 2005. Water Resources Program, Guidance 1210, Determining Irrigation Efficiency and Consumptive Use. Washington State, Department of Ecology, p. 11. https://fortress.wa.gov/ecy/wrdocs/WaterRights/wrwebpdf/guid1210.pdf

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