Appendix H – Permit-Exempt Growth and Consumptive Use Summary Technical Memo

To:	Angela Johnson, Washington State Department of Ecology
From:	Chad Wiseman, HDR, Malia Bassett, HDR
Copy:	
Date:	July 6, 2020
Subject:	WRIA 14 Permit-Exempt Growth and Consumptive Use Summary (Work Assignment 2, Tasks 2 and 3)

Introduction

HDR is providing technical support to the Washington State Department of Ecology (Ecology) and the Watershed Restoration and Enhancement (WRE) committees for Water Resource Inventory Area 14. This memorandum provides a summary of the analytical methods used for Work Assignment 2 Task 2: Consumptive Use (CU) Estimates, and the final estimates of consumptive use per WRIA.

Under Revised Code of Washington (RCW) 90.94, consumptive water use by permit-exempt connections occurring over the planning horizon must be estimated to establish the water use that watershed restoration plans and plan updates are required to address and offset. This memorandum summarizes permit-exempt connections and related consumptive use of groundwater that is projected to impact WRIA 14 over the planning horizon.

This memorandum includes:

- A summary of WRIA 14 initial permit-exempt growth and an alternative scenario of permit-exempt growth.
- A summary of WRIA 14 initial and alternative scenario consumptive use using two different methods.

WRIA 14 Permit-Exempt Growth Projection Methods

Permit-exempt growth over the planning horizon was projected using methods at the county scale and then combined at the WRIA scale. HDR worked directly with Mason County to develop and implement growth projection methods. Thurston County (working with the Thurston Regional Planning Council) provided methods and results for Thurston County.

HDR worked with the WRIA 14 workgroup and Committee to define one alternative growth scenario that allowed for some permit-exempt growth in water system boundaries based on the proportion of parcels not currently served by their respective water systems.

Mason County

The Mason County initial permit-exempt growth projections were developed using the following methods:

1. Develop growth projections based on the Mason County Comprehensive Plan (the comprehensive plan is based on Office of Financial Management (OFM) medium population growth estimates, and conversion to dwelling units based on assumed people per dwelling unit).
2. Determine available land for single family domestic units and determine proportion of build-out capacity by county Urban Growth Areas (UGAs) and rural lands.
3. Apply growth projections to buildable lands.
4. Overlay subbasins to determine new permit-exempt connections in each subbasin.

Initial growth projections for Mason County have increased, based on updating parcel data for the application of growth projections to buildable lands (i.e., parcels that were streets or waterbodies). The results were organized by subbasin. The distribution of projected permit-exempt growth within subbasins was reported with a heat map.

An alternative permit-exempt growth projection scenario was developed by assuming that some permit-exempt growth will occur in water system areas. It was assumed that growth in each respective water system will be proportional to buildable parcels without water system hookups relative to parcels with water system hookups. The following methods were applied on top of the initial methods:

1. Define total buildable parcels in GIS, using Department of Health (DOH) service area polygons and county parcel data.
2. Define total approved water system connections (built out + available) and active water system connections (built out) using the DOH Sentry database (DOH 2019).
3. Buildable parcels with water system hookup = total approved minus active water system connections.
4. Buildable parcels without water system hookup = total buildable parcels minus total approved water system connections.
5. Define proportion of permit-exempt growth within each water system by dividing number of buildable parcels without water system hookups by total number of buildable parcels.
6. Multiply proportion of permit-exempt growth within each respective water system by total growth projected to occur in that water system.
7. Sum additional permit-exempt growth by subbasin and add to initial permit-exempt growth projection.

Thurston County Methods

The Thurston County initial permit-exempt growth projections were developed using the following methods:

1. Develop 20-year growth projections based on OFM medium population growth estimates, and conversion to dwelling units based on assumed people per dwelling unit
2. Develop residential capacity estimates.
3. Allocate growth to parcels based on recent residential development and permit trends, where capacity is available.
4. Estimate the amount of development on permit-exempt connections based on the following criteria provided by Thurston County:
    a) Located outside incorporated cities; growth in incorporated cities is assumed to connect to a municipal water system.
    b) Water systems within UGAs; permit-exempt growth is assumed to occur on parcels with no sewer service.
    c) Rural water systems; assumed no permit-exempt growth.

These Thurston County growth projection methods and results have not changed since the original estimate was provided to Ecology and the WRIA 14 WRE Committee (HDR 2019; Appendix B). The results were calculated for the Thurston County portion of the Kennedy subbasin. The distribution of projected permit-exempt growth within subbasins was further defined using a buildable lands analysis and was reported with a heat map (Appendix B).

An alternative permit-exempt growth projection scenario was developed by assuming that some permit-exempt growth will occur in the rural water system areas. It was assumed growth in each respective water system will be proportional to buildable parcels without water system hookups relative to parcels with water system hookups. The methods defined for the Mason County alternative growth scenario (see Mason County above) were used to define permit-exempt growth in these rural water systems.

WRIA 14 Consumptive Use Methods

Under RCW 90.94, consumptive water use (consumptive use) by permit-exempt connections that are forecast to be installed over the planning horizon to service rural growth must be estimated to establish the water offsets required under the Streamflow Restoration law. The following definitions from the *Final Guidance for Determining Net Ecological Benefit - ESSB 6091 - Recommendations for Water Use Estimates* (Ecology's Final NEB Guidance) are used in this memorandum as a guide to estimate consumptive water use by permit-exempt connections (Ecology 2019).

- Consumptive Use: water that evaporates, transpires, is consumed by humans, or is otherwise removed from an immediate water environment.

- Domestic Use: includes both indoor and outdoor household uses, and watering of a lawn and noncommercial garden.
- New Consumptive Water Use: The consumptive water use from the permit-exempt domestic groundwater withdrawals estimated to be initiated within the 20-year planning horizon (2020–2040; planning horizon). The required water offset is equal to new consumptive water use.
- Net Ecological Benefit: The outcome that is anticipated to occur through implementation of projects and actions in a plan to yield offsets that exceed impacts within (a) the planning horizon and (b) the relevant WRIA boundary.
- Water Offsets: Projects that put water back into aquifers or streams that offset new consumptive water use.

Ecology has provided guidance for estimating indoor and outdoor consumptive water use in Ecology's Final NEB Guidance (Ecology 2019).

Consumptive use estimates are divided into two components: the indoor and outdoor portions of use. The use patterns and consumptive portions of indoor versus outdoor use associated with permit-exempt connections are different; therefore, separate approaches within each method that account for these differences are used to estimate consumptive use.

Ecology's indoor consumptive water use guidance includes literature-based assumptions on per-capita indoor water use and the consumptive proportion. Outdoor consumptive water use guidance includes methods for the estimation of irrigated area, assumed irrigation requirements, irrigation efficiency, and the consumptive proportion. Ecology's guidance also recommends local corroboration using water system meter data for both indoor and outdoor estimates (Ecology 2018, 2019). For purposes of this technical memorandum, Ecology's method for estimating consumptive use is called the Irrigated Area method, and estimation of consumptive use using local water system meter data is called the Water System Data method.

Consistent with the Final NEB guidance, the Committee assumed that impacts from consumptive use on surface water are steady-state, meaning that impacts to the stream from pumping do not change over time. This assumption is based on the wide distribution of future well locations and depths across varying hydrogeological conditions.

Irrigated Area Method

Based on Ecology's Final NEB Guidance (Ecology 2019), estimating indoor and outdoor consumptive water use included literature-based assumptions for both the per capita indoor water use and indoor and outdoor use proportions.

Indoor Consumptive Use – Irrigated Area Method

The following assumptions were used to estimate indoor consumptive water use by occupants of a dwelling unit (Ecology 2018, 2019):

- 60 gallons per day (gpd) per person within a household

- 2.5 persons per household (or as otherwise defined by the Counties)
- 10 percent of indoor use is consumptively used

Most homes served by a permit-exempt connection use septic systems for wastewater (Ecology 2019). This method assumes that 10 percent of water entering the septic system will evaporate out of the septic drain field and the rest will be returned to the groundwater system.

Assuming that there is one permit-exempt connection per dwelling unit, a "per permit-exempt connection" consumptive use factor was applied to the growth projections forecast in each subbasin to determine total indoor consumptive use per subbasin. This method is summarized by the following equation:

$$HCIWU\ (gpd) = 60\ gpd\ x\ 2.5\ people\ per\ household\ x\ 10\%\ CUF$$

or

$$HCIWU\ (afy) = 60 gpd * 2.5\ people\ per\ house * 365\ days * 0.00000307\ AF/gallon * 10\%\ CUF$$

Where:

HCIWU = Household Consumptive Indoor Water Use (gpd)

afy = acre-feet per year

CUF = Consumptive use factor

This estimate of indoor consumptive water use per household is 15 gpd and can be annualized and converted to acre-feet per year (AFY) or cubic feet per second (cfs).

Outdoor Consumptive Use – Irrigated Area Method

Ecology (2018, 2019) recommends estimating future outdoor water use based on an evaluation of the average outdoor irrigated area for existing dwelling units served by permit-exempt connections. To calculate the consumptive portion of total outdoor water required per connection, Ecology recommends:

- Estimating the average irrigated lawn area (pasture/turf grass) per parcel;
- Applying crop irrigation requirements;
- Correcting for application efficiency (75 percent efficiency recommended by Ecology Guidance) to determine the total outdoor water required over a single growing season; and
- Applying a percentage of outdoor water that is assumed to be consumptive. This method assumes that 80 percent of outdoor domestic water use is consumed by evaporation and transpiration.

Future outdoor water use may be based, in part, on an estimate of the average outdoor irrigated area for existing homes served by permit-exempt domestic wells (Ecology 2018, 2019). HDR estimated the average irrigated lawn area for WRIA 14 by delineating the apparent

irrigated area in 80 parcels identified as containing a dwelling unit served by a permit-exempt well in WRIA 14, and averaging them (Attachment A). The irrigated areas were delineated using one technician and a standard method. The average irrigated area per permit-exempt connection in WRIA 14 was estimated to be 0.07 acre. The majority of the parcels evaluated did not have an apparent irrigated area (i.e., most parcels had no irrigated area).

Bias in the irrigated area delineation methods was evaluated by doing a side-by-side comparison study with another consulting form that was providing similar technical support for the WRIA 7, 8, and 9 WRE plans. This comparability study concluded that there was no inherent bias in the methods. Overall method bias was also evaluated by comparing the CU calculated with the Irrigated Area method to specific parcels with meter records (Attachment B). The Irrigated Area method overestimated overall water use, relative to the actual metered use.

Because of the high proportion of zero irrigated acreage measurements contributing to the 0.07-acre irrigated acreage average, and because of the large variability in the results (i.e., large standard deviation), HDR proposed a range of alternatives to mitigate that uncertainty:

- To account for the uncertainty of detecting small areas of irrigation, the Committee could impute the zero values with a "minimum detection" irrigated area of 0.05 acre, which would result in a 0.10-acre average irrigated area size.
- HDR completed an irrigated area comparability study for the irrigated area parcel analysis, and determined that an additional way to account for uncertainty in "human error" could be done using a "correction factor," which would result in a 0.11-acre average irrigated area size.
- HDR has completed a statistical analysis of their data, and has determined that using the 95 percent Upper Confidence Limit of the data (based on initial analysis with 0 values) could be an additional way to account for uncertainty, which would result in a 0.14-acre average irrigated area size.

Initially, the WRIA 14 Committee decided to move forward with a "primary working number" and a "working number for comparison." The primary working number is an average irrigated acreage of 0.10 acre (average value with imputed minimum detection values of 0.05 acre). The working number for comparison is 0.14 acre, which is the non-parametric 95th Upper Confidence Limit of the mean. Consumptive use based on both acreages were evaluated and compared to the consumptive use calculated from the Water System Data Method. The Committee later agreed by consensus to include the consumptive use estimate based on the 0.10 acre average irrigated area as the "most likely" estimate in the plan, and the consumptive use estimate based on the 0.14 acre average irrigated area as a higher goal to achieve through adaptive management.

Crop irrigation requirements, irrigation efficiency and outdoor use assumptions were also made to estimate outdoor consumptive use. An average crop irrigation requirement of 18 inches per year was estimated for pasture/turf grass from nearby stations as provided in the Washington

Irrigation Guide (NRCS-USDA 1997). Irrigation application efficiency (i.e., the percent of water used that actually reaches the turf) was assumed to be 75 percent, consistent with Ecology (2018, 2019) recommendations. Finally, the consumptive portion of total amount of water used for outdoor use was assumed to be 80 percent. The WRIA 14 Committee chose not to modify the irrigation efficiency or indoor and outdoor consumptive factors used in the Irrigation Area method.

This method is summarized in the following equation:

$$HCOWU\ (afy) = A\ (acres) * IR(feet) * AE * CUF$$

Where:

HCOWU = Household Consumptive Outdoor Water Use (gpd)

afy = acre-feet per year

A = Irrigated Area (acres)

IR = Irrigation Requirement over one irrigation season (feet)

AE = Application Efficiency; assumed to be 75 percent (factor expressed as 1/0.75)

CUF = Consumptive Use Factor; assumed to be 80 percent (factor expressed as 0.80)

This estimate of outdoor consumptive water use per household per day can be annualized and converted to gallons per day or cubic feet per second.

Conversion Factors:

gpd = afy * 0.001120

cfs = afy * 723.97

This estimate of outdoor consumptive use per household per day is 143 gpd (assuming average irrigated area of 0.10 acre) and 200 gpd (assuming average irrigated area of 0.14 acre) and can be annualized and converted to acre-feet per year of cubic feet per second.

Seasonal consumptive use was estimated on a monthly basis by allocating total outdoor consumptive use proportional to the monthly irrigation requirement. The monthly irrigation requirement was defined by the Washington Irrigation Guidance.

Water System Data Method

Consumptive use by permit-exempt connections may also be estimated using metered connections from water systems. Water systems required to plan per Washington Administrative Code 246–290 must install meters on all customer connections. Smaller water systems that do not have state planning requirements may choose to meter their customer connections if the system billing is based on a tiered rate structure (i.e., increasing costs per unit of water consumed coincident with higher total use in the billing period).

Some systems bill customers a flat rate (i.e., same bill every month regardless of consumption). The lack of a tiered rate structure reduces the financial incentive to conserve water, which may result in consumption patterns more similar to those observed on a permit-exempt connection. These systems may or may not choose to meter their customers if meters are not required by law.

No water use meter data were available for systems that uses a flat rate structure. The Cherry Park, Union, and Harstene Island water systems operate under a tiered rate structure in WRIA 14 and were utilized for this analysis.

In most instances pumping impacts associated with new permit-exempt domestic withdrawals will be quite small, well dispersed, and nearly steady-state with respect to streams, as stated in Ecology's final NEB Guidance Appendix B (Ecology, 2019).

Indoor Use

Average daily use in December, January, and February is representative of year-round daily indoor use. Average daily system-wide use is divided by the number of permit-exempt connections (assuming all connections are residential) to determine average daily indoor use per permit-exempt connection. Similar to that used in the Ecology Irrigated Area method, a 10 percent consumptive use factor was applied to the average daily use in the winter months to determine the consumptive portion of indoor water use per connection.

Annual Outdoor Water Use

Average daily indoor use was multiplied by the number of days in a year to estimate total annual indoor use. Total annual indoor use was then subtracted from total annual use by a water system to estimate total annual outdoor use. Similar to the calculation used in the Ecology Irrigated Area Method, an 80 percent consumptive factor was applied to determine the consumptive portion of outdoor use.

Seasonal Outdoor Water Use

Outdoor consumptive use was also estimated on a seasonal basis. The Washington Irrigation Guide reports irrigation requirements between the months of April and September for representative weather stations in WRIA 14; therefore, seasonal outdoor water use was assumed to occur over a period of 6 months (April through September). Average daily indoor use was multiplied by the number of days in the irrigation season to calculate total indoor use for the irrigation season. Total irrigation season indoor use was then subtracted from total season use to determine total outdoor use for the irrigation season. The value was proportionally allocated to each month in the irrigation season using the requirements from the Washington Irrigation Guide. An 80 percent consumptive factor was applied to determine the consumptive portion of outdoor use.

Results

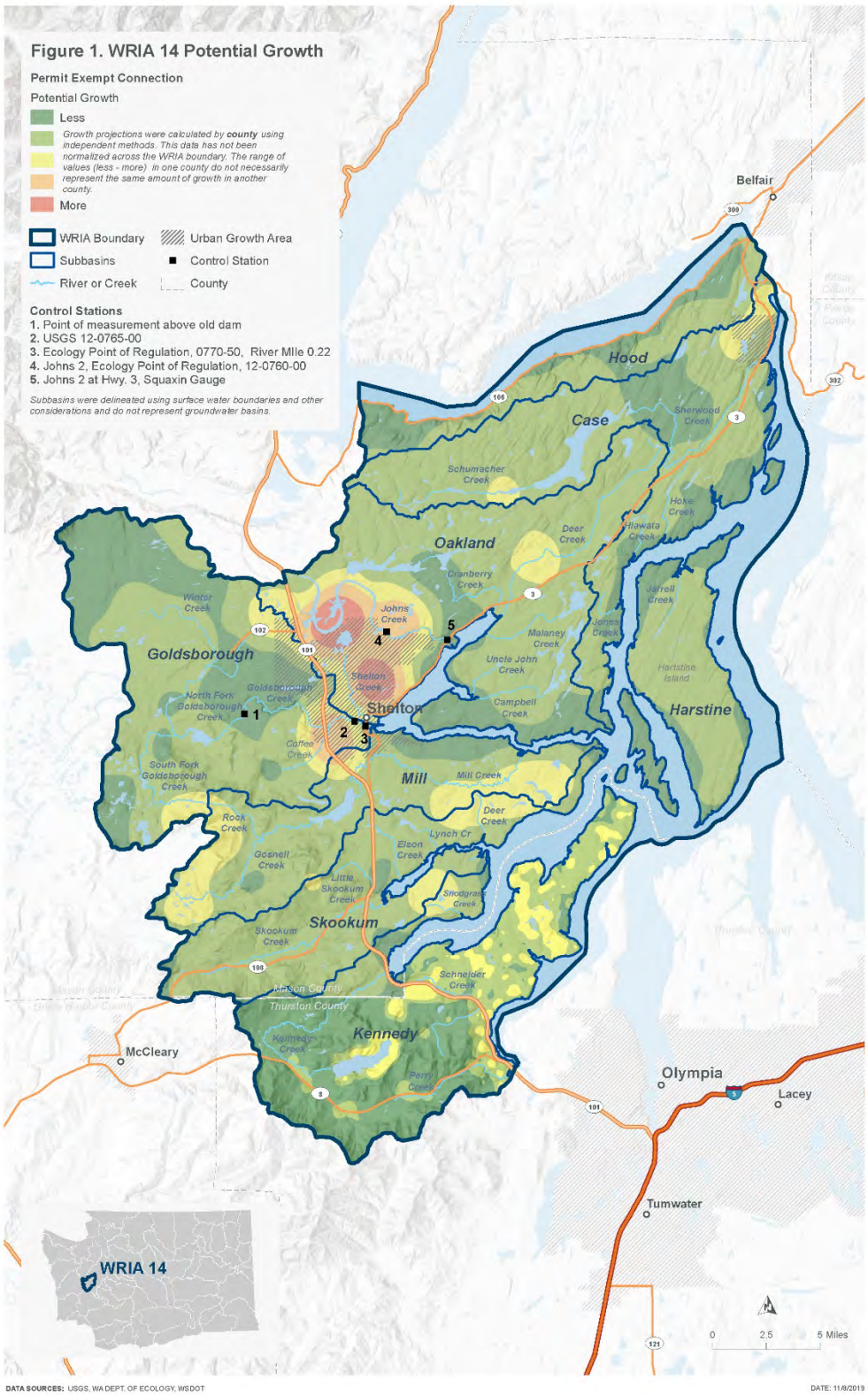
Permit-Exempt Connection Growth

Initial permit-exempt connection growth is projected to be 4,006 connections (Table 1). The alternative revised permit-exempt connection growth scenario is projected to have 288 additional connections, for a total of 4,294 permit-exempt connections. The WRIA 14 Committee has not selected one projection over the other for consumptive use estimation. Permit-exempt connection growth is expected to be greatest in the Oakland Bay subbasin.

Table 1: WRIA 14 Alternative Growth Projection Scenarios

Number of Permit-Exempt Wells Added between 2018 and 2038		
Subbasin	**Initial**	**Revised**
Case	418	512
Goldsborough	509	546
Harstine	143	143
Hood	74	117
Kennedy	556	588
Mill	462	466
Oakland	1,481	1559
Skookum	363	363
Totals	**4,006**	**4,294**

Figure 1. WRIA 14 Projected Permit-Exempt Connection Growth



Consumptive Use

The WRIA-wide consumptive use estimates used the Irrigated Area method range from 0.98 cfs (initial, average irrigated area of 0.10 acre) to 1.05 cfs (revised growth, average irrigated area of 0.10 acre) (Table 2 and Table 3). When an average irrigated area of 0.14 acre (95 percent Upper Confidence Limit [UCL] average irrigated area) was assumed, the consumptive use estimates ranged from 1.33 cfs (initial) to 1.43 cfs (revised growth).

The water system data analysis in WRIA 14 was conducted using averages of three systems managed by the Mason Public Utility District: Cherry Park, Union, and Harstene Retreat. The WRIA-wide consumptive use estimate calculated using the Water System Data method ranged from 0.48 cfs (initial) to 0.51 cfs (revised growth) (Table 2 and Table 3).

The WRIA 14 Committee selected the Irrigated Area method, using an average irrigated area of 0.10 acre as the "working" consumptive use estimate. The consumptive use estimates using a 95 percent UCL of the average irrigated area (0.14 acre) and the water system data method are for comparative purposes only.

Estimates of consumptive use using the Irrigated Area method are approximately two times greater than the Water System Data estimates.

Seasonal Use

Monthly outdoor water use was calculated as part of the consumptive use analysis for the Irrigated Area method. Seasonal water use by month is reported by subbasin and scenario (Table 4 and Table 5). The month of July has the highest irrigation requirement, resulting in the highest monthly consumptive use impact. This information may be used during evaluation of projects designed to offset subbasin- and season-specific impacts.

Sources

Ecology. 2018. *Recommendations for Water Use Estimates*. Washington State Department of Ecology, Publication 18-11-007.

Ecology. 2019. Final Guidance for Determining Net Ecological Benefit. Washington State Department of Ecology, Publication 19-11-079.

Natural Resource Conservation Service. 1997. Washington Irrigation Guide (WAIG). U.S. Department of Agriculture.

Table 2: Annualized Average Consumptive Use Estimates for WRIA 14 (2020–2040) – Initial Growth

Subbasin	Projected No. Permit-Exempt Wells	Annual Consumptive Use: Water System Estimate			Annual Consumptive Use: Irrigated Area Estimate (0.10 acre average irrigated area)			Annual Consumptive Use: Irrigated Area Estimate (0.14 acre average irrigated area)		
		AFY	GPM	AFY	AFY	GPM	CFS	AFY	GPM	CFS
Case	418	36.2	22.4	0.05	73.9	45.8	0.10	100.7	62.4	0.14
Goldsborough	509	44.0	27.3	0.06	90.0	55.8	0.12	122.6	76.0	0.17
Harstine	143	12.4	7.7	0.02	25.3	15.7	0.03	34.4	21.3	0.05
Hood	74	6.4	4.0	0.01	13.1	8.1	0.02	17.8	11.0	0.02
Kennedy	556	48.1	29.8	0.07	98.3	60.9	0.14	133.9	83.0	0.19
Mill	462	40.0	24.8	0.06	81.7	50.6	0.11	111.3	69.0	0.15
Oakland	1,481	128.2	79.4	0.18	261.8	162.3	0.36	356.6	221.1	0.49
Skookum	363	31.4	19.5	0.04	64.2	39.8	0.09	87.4	54.2	0.12
Totals	**4,006**	**346.7**	**214.9**	**0.48**	708.3	439.1	0.98	964.7	598.0	1.33

Table 3: Annualized Average Consumptive Use Estimates for WRIA 14 (2020–2040) – Revised Permit-exempt Connection Growth

Subbasin	Projected No. Permit-Exempt Wells	Annual Consumptive Use: Water System Estimate			Annual Consumptive Use: Irrigated Area Estimate (0.10 acre average irrigated area)			Annual Consumptive Use: Irrigated Area Estimate (0.14 acre average irrigated area)		
		AFY	GPM	CFS	AFY	GPM	CFS	AFY	GPM	CFS
Case	512	44.3	27.5	0.06	90.5	56.1	0.13	123.3	76.4	0.17
Goldsborough	546	47.2	29.3	0.07	96.5	59.8	0.13	131.5	81.5	0.18
Harstine	143	12.4	7.7	0.02	25.3	15.7	0.04	34.5	21.4	0.05
Hood	117	10.1	6.3	0.01	20.7	12.8	0.03	28.2	17.5	0.04
Kennedy	588	50.9	31.5	0.07	103.9	64.4	0.14	141.5	87.7	0.20
Mill	466	40.3	25.0	0.06	82.4	51.1	0.11	112.2	69.6	0.16
Oakland	1559	134.9	83.6	0.19	275.6	170.9	0.38	375.4	232.7	0.52
Skookum	363	31.4	19.5	0.04	64.2	39.8	0.09	87.4	54.2	0.12
Totals	**4,294**	**371.6**	**230.4**	**0.51**	759.2	470.6	1.05	1,034.0	641.0	1.43

Table 4: WRIA 14 Monthly Consumptive Water Use (Irrigated Area method; assumed irrigated area of 0.10 acres)

Subbasin	Projected No. Permit-exempt Connections	Consumptive Use by Month (cfs)											
		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Initial													
Case	418	0.00	0.00	0.00	0.02	0.18	0.24	0.33	0.25	0.10	0.00	0.00	0.00
Goldsborough	509	0.00	0.00	0.00	0.03	0.21	0.29	0.40	0.31	0.12	0.00	0.00	0.00
Harstine	143	0.00	0.00	0.00	0.01	0.06	0.08	0.11	0.09	0.03	0.00	0.00	0.00
Hood	74	0.00	0.00	0.00	0.00	0.03	0.04	0.06	0.04	0.02	0.00	0.00	0.00
Kennedy	556	0.01	0.01	0.01	0.03	0.23	0.32	0.44	0.34	0.14	0.01	0.01	0.01
Mill	462	0.00	0.00	0.00	0.03	0.19	0.27	0.36	0.28	0.11	0.00	0.00	0.00
Oakland	1,481	0.01	0.01	0.01	0.08	0.62	0.85	1.17	0.90	0.36	0.01	0.01	0.01
Skookum	363	0.00	0.00	0.00	0.02	0.15	0.21	0.29	0.22	0.09	0.00	0.00	0.00
Totals	**4,006**	0.04	0.04	0.04	0.22	1.69	2.31	3.15	2.43	0.97	0.04	0.04	0.04
Higher Permit-Exempt Connection Growth													
Case	512	0.00	0.00	0.00	0.03	0.22	0.29	0.40	0.31	0.12	0.00	0.00	0.00
Goldsborough	546	0.01	0.01	0.01	0.03	0.23	0.31	0.43	0.33	0.13	0.01	0.01	0.01
Harstine	143	0.00	0.00	0.00	0.01	0.06	0.08	0.11	0.09	0.03	0.00	0.00	0.00
Hood	117	0.00	0.00	0.00	0.01	0.05	0.07	0.09	0.07	0.03	0.00	0.00	0.00
Kennedy	588	0.01	0.01	0.01	0.03	0.25	0.34	0.46	0.36	0.14	0.01	0.01	0.01
Mill	466	0.00	0.00	0.00	0.03	0.20	0.27	0.37	0.28	0.11	0.00	0.00	0.00
Oakland	1,559	0.01	0.01	0.01	0.09	0.66	0.90	1.23	0.95	0.38	0.01	0.01	0.01
Skookum	363	0.00	0.00	0.00	0.02	0.15	0.21	0.29	0.22	0.09	0.00	0.00	0.00
Totals	**4,294**	0.04	0.04	0.04	0.24	1.81	2.47	3.38	2.61	1.04	0.04	0.04	0.04

Note: WRIA 14 did not consider a low-growth scenario.

Table 5: WRIA 14 Monthly Consumptive Water Use (Irrigated Area method; assumed irrigated area of 0.14 acres)

Subbasin	Projected No. Permit-exempt Connections	Consumptive Use by Month (cfs)											
		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Initial													
Case	418	0.00	0.00	0.00	0.03	0.25	0.34	0.46	0.35	0.14	0.00	0.00	0.00
Goldsborough	509	0.00	0.00	0.00	0.04	0.30	0.41	0.56	0.43	0.17	0.00	0.00	0.00
Harstine	143	0.00	0.00	0.00	0.01	0.08	0.11	0.16	0.12	0.05	0.00	0.00	0.00

Hood	74	0.00	0.00	0.00	0.01	0.04	0.06	0.08	0.06	0.02	0.00	0.00	0.00
Kennedy	556	0.01	0.01	0.01	0.04	0.33	0.45	0.61	0.47	0.19	0.01	0.01	0.01
Mill	462	0.00	0.00	0.00	0.03	0.27	0.37	0.51	0.39	0.16	0.00	0.00	0.00
Oakland	1,481	0.01	0.01	0.01	0.11	0.87	1.19	1.63	1.25	0.50	0.01	0.01	0.01
Skookum	363	0.00	0.00	0.00	0.03	0.21	0.29	0.40	0.31	0.12	0.00	0.00	0.00
Totals	**4,006**	0.04	0.04	0.04	0.30	2.35	3.21	4.40	3.39	1.35	0.04	0.04	0.04
Higher Permit-Exempt Connection Growth													
Case	512	0.00	0.00	0.00	0.04	0.30	0.41	0.56	0.43	0.17	0.00	0.00	0.00
Goldsborough	546	0.01	0.01	0.01	0.04	0.32	0.44	0.60	0.46	0.18	0.01	0.01	0.01
Harstine	143	0.00	0.00	0.00	0.01	0.08	0.11	0.16	0.12	0.05	0.00	0.00	0.00
Hood	117	0.00	0.00	0.00	0.01	0.07	0.09	0.13	0.10	0.04	0.00	0.00	0.00
Kennedy	588	0.01	0.01	0.01	0.04	0.34	0.47	0.65	0.50	0.20	0.01	0.01	0.01
Mill	466	0.00	0.00	0.00	0.03	0.27	0.37	0.51	0.39	0.16	0.00	0.00	0.00
Oakland	1,559	0.01	0.01	0.01	0.12	0.91	1.25	1.71	1.32	0.53	0.01	0.01	0.01
Skookum	363	0.00	0.00	0.00	0.03	0.21	0.29	0.40	0.31	0.12	0.00	0.00	0.00
Totals	**4,294**	0.04	0.04	0.04	0.32	2.52	3.44	4.71	3.63	1.45	0.04	0.04	0.04

Note: WRIA 14 did not consider a low-growth scenario.

Attachment A

Estimation of Average Irrigated Area

Methods

1. 80 parcels representing an existing dwelling served by a permit-exempt well or connection was defined.
    a. A pool of parcels with an existing dwelling served by a permit-exempt well or connection was defined.
    b. The selection pool was classified by property value. The classes were (1) Under $350,000, (2) $350,000–$600,000, and (3) more than $600,000.
    c. 80 parcels were randomly drawn from the selection pool, weighted by the proportion of property value class membership.
    d. Additional parcels were randomly selected as alternates, in case any of the primary (80) samples were able to be interpreted to irrigated area.
    e. All parcels were provided in a GoogleEarth .kmz file.
2. The irrigated area in each parcel was delineated according to the following procedure:
    a. Used a single technician to minimize operator variability.
    b. Irrigated area delineations were made using GoogleEarth aerial imagery taken during drier summer months (i.e., July and August). Unirrigated lawns (pasture/turf) go dormant in the dry summer months and turn brown. As such, areas that remain green in the summer imagery were considered irrigated.
    c. Aerial imagery from winter months was reviewed alongside summer imagery to reveal which lawn areas change from green to brown. Those areas that do not change color, or moderately change color but remain green, were considered irrigated.
    d. If available, multiple years of aerial imagery were used to corroborate the irrigated area delineation.
    e. Landscaped shrub/flower bed areas within a larger irrigated footprint were included. Shrub and flower bed areas outside of the irrigated footprint were excluded.
    f. If the irrigated area extended beyond the parcel boundary, those areas were included.
    g. Parcels with no visible signs of irrigation were assumed to have zero irrigated acres.
    h. Areas that appeared to be native forest or unmaintained grass were not included in the irrigated footprint.

i. Parcels with homes or accessory dwelling units (ADUs) under construction in the most recent GoogleEarth imagery were excluded from the analysis, and an alternate parcel was evaluated.

- Figures B-1 through B-4 illustrate some example delineations.

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Figure B-1. No irrigated areas visible in most recent GoogleEarth aerial imagery.

Figure B-2. Area in white includes maintained grass. Residence constructed between June 2017 and July 2018. Therefore, historical irrigation of property is unavailable in GoogleEarth imagery.

Figure B-3. Irrigated area includes landscaped area in driveway, maintained yard around residence, garden area, and maintained grass near garden area.

Figure B-4. No irrigated area. Assumption that green vegeation on southern portion of parcel is due to proximity to Spurgeon Creek since clear delineation of irrigated area is not present on aerial. Green area near residence appears to be tree and shrubs, not maintained landscaping and is excluded.

Results

Eighty parcels were evaluated for irrigated acreage (Figure B-5). The average irrigated acreage was 0.07 acre (Table B-1). In all WRIAs evaluated, most parcels had zero irrigated acres (Figure B-6). The distribution of irrigated acreages for all WRIAs were skewed because of the large percentage of parcels that had zero irrigated acres. Some parcels had an irrigated area nearly an order of magnitude larger than the mean, resulting in a large standard deviation. The 95 percent upper confidence limit of the mean could be fit only with a non-parametric distribution and was about twice the quantity of the calculated arithmetic mean. When a minimum irrigated acreage of 0.05 acre was imputed for the parcels with zero irrigated acres observed, the average acreage increased to 0.10 acre.

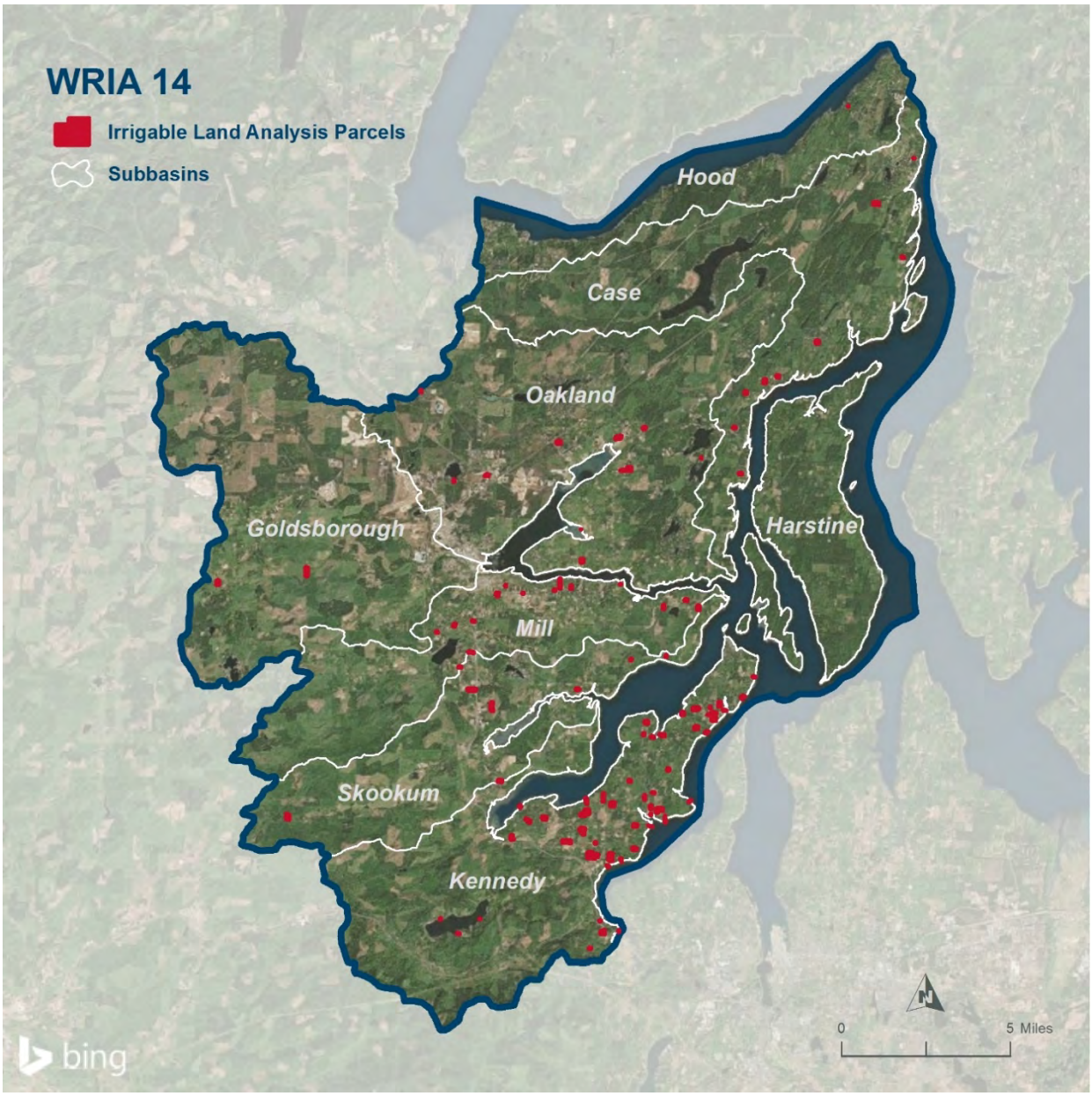

Figure B-5. Parcels selected in WRIA 14 with existing permit-exempt connections that were delineated for apparent irrigated areas.

Table B-1. Irrigated acreage delineation results

Statistic	WRIA 14
Permit-exempt Parcel Sample Pool	5,091
Sample Size	80
Mean (acres)	0.07
Mean, with 0.05-acre minimum (acres)	0.10

Standard Deviation (acres)	0.15
95% UCL (acres)	0.14

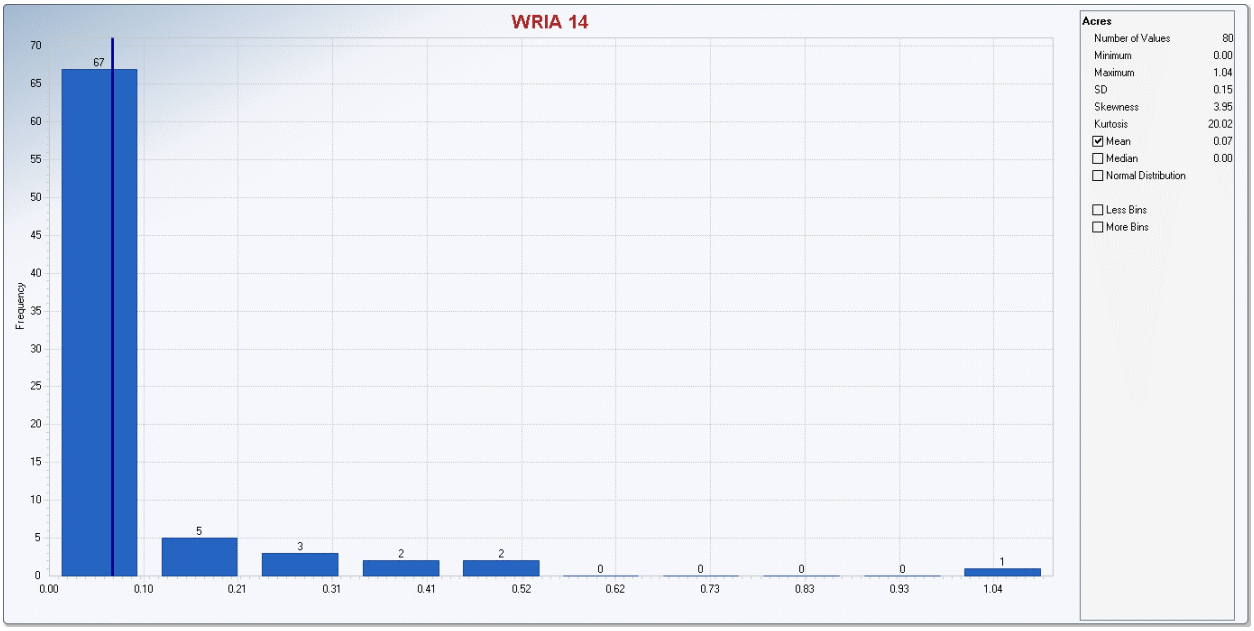

Figure B-6. Histogram of WRIA 14 irrigated acreage delineation results.

Because of the large proportion of parcels with zero acres observed, and the large variability in the results (i.e., large standard deviation), HDR proposed a range of alternatives to mitigate that uncertainty:

- To account for uncertainty of detecting small areas of irrigation, the Committee could impute the zero values with a "minimum detection" irrigated area of 0.05 acre, which would result in a 0.10-acre average irrigated area size.
- HDR completed an irrigated area comparability study for the irrigated area parcel analysis, and determined that an additional way to account for uncertainty in "human error" could be done using a "correction factor," which would result in a 0.11-acre average irrigated area size.
- HDR has completed a statistical analysis of their data, and has determined that using the 95 percent Upper Confidence Limit of the data (based on initial analysis with 0 values) could be an additional way to account for uncertainty, which would result in a 0.14-acre average irrigated area size.

The WRIA 14 Committee decided to move forward with a "primary working number" and a "working number for comparison." The primary working number is an average irrigated acreage

of 0.10 acre (average value with imputed minimum detection values of 0.05 acre). The working number for comparison is 0.14 acre, which is the non-parametric 95th Upper Confidence Limit of the mean. Consumptive use based on both acreages will be evaluated and compared to the consumptive use calculated from the Water System Data method.

Attachment B

Consumptive Use Corroboration Analysis

Thurston, Mason, and Kitsap PUDs provided water consumption data for several systems with a small number of connections. These systems were analyzed using both consumptive use estimation methods. All parcels in each system were analyzed for irrigated area, providing a direct comparison between the water estimated using the Irrigated Area method and the actual measured consumption by the water system. Table 1 contains the results of the corroboration analysis.

Table 1: Annual and Seasonal Consumptive Use Corroboration Analysis

WRIA – Water System	Annual Consumptive Use (gpd per household)			Seasonal Consumptive Use (gpd per household)					
				Summer			Winter		
	Water System Data	Irrigated Area Method	Percent Difference[1]	Water System Data	Irrigated Area Method	Percent Difference[1]	Water System Data	Irrigated Area Method	Percent Difference[1]
WRIA 12 – Whiskey Hollow	53.6	181.1	238	85.8	346.3	304	11.2	15.0	34
WRIA 13 – Rich Road	52.6	113.2	115	86.8	210.8	143	7.3	15.0	107
WRIA 14 – Canyonwood Beach	29.3	86.4	195	51.2	157.4	207	7.2	15.0	107
WRIA 15 – Echo Valley	76.7	75.5	-2	137.9	135.7	-2	15.2	15.0	-1

[1]Change in consumptive use from the Water System Data method to the Irrigated Area method.

The Irrigated Area method estimated consumptive use values at least double those estimated from the Water System Data method in WRIAs 12, 13, and 14. This is true for both indoor and outdoor use. The exception is winter consumptive use in the Whiskey Hollow system, which suggests that customers purchasing water from Whiskey Hollow use indoor water at a rate similar to that assumed in the Irrigated Area method (i.e., 60 gpd per person). The Echo Valley system in WRIA 15 has a slight decrease in estimated consumptive use in the Irrigated Area method compared to the Water System Data method. Customers in this system may heavily irrigate their lawns, or the estimate of total irrigated area in the system may be biased low. No small water system data were provided in WRIA 10.