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

Technical Memorandum DRAFT

To:	Angela Johnson, Washington State Department of Ecology
From:	Chad Wiseman, HDR
Copy:	
Date:	July 14, 2020
Subject:	WRIA 13 Permit-Exempt Growth and Consumptive Use Summary (Work Assignment 2, Tasks 2 and 3)

1.0 Introduction

HDR is providing technical support to the Washington State Department of Ecology (Ecology) and the Watershed Restoration and Enhancement (WRE) committees for WRIA 13. 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 CU per WRIA.

Under 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 CU of groundwater that is projected to impact WRIA 13 over the planning horizon.

This memorandum includes:

- A summary of WRIA 13 initial permit-exempt growth and an alternative scenario of permit-exempt growth.
- A summary of WRIA 13 initial and alternative scenario consumptive use using two different methods.

2.0 WRIA 13 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. Thurston County (working with the Thurston Regional Planning Council) provided methods and results for Thurston County. Note that Thurston County and Lewis County are both within WRIA 13; however, the Lewis County portion is entirely comprised of timberland and so was not included in the projection for new PE wells.

HDR worked with the WRIA 13 workgroup and WRIA 13 committee (the Committee) to define one alternative growth scenario that allowed for some permit-exempt growth in rural water system boundaries based on the proportion of parcels not currently served by their respective water system.

2.1 Thurston County Methods

The Thurston County initial permit-exempt growth projections were developed by the Thurston Regional Planning Council (TRPC) (Appendix A). The following is a summary of the TRPC 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 (TRPC).
2) Develop residential capacity estimates (TRPC).
3) Allocate growth to parcels based on recent residential development and permit trends, where capacity is available (TRPC).
4) Once allocated, define permit-exempt connections based on the following criteria:
    a) Growth in rural areas, outside of water systems, is assumed to be permit-exempt growth.
    b) Growth in incorporated cities is assumed to connect to a municipal water system
    c) Water systems within UGAs; permit-exempt growth is assumed to occur on parcels with no sewer service.
    d) Rural water systems; assumed no new permit-exempt growth

An alternative permit-exempt growth projection scenario was developed by assuming that some permit-exempt growth will occur in the rural water system areas (i.e. water systems outside of the urban growth areas). It was assumed growth in each respective rural water system will be proportional to buildable parcels without water system hookups relative to parcels with water system hookups, which changes the assumption in 4b above.

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 (active + available) and active water system connections 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 projected permit-exempt growth within each water system by dividing the number of buildable parcels without water system hookups by the total number of buildable parcels.
6. Multiply the proportion of permit-exempt growth within each respective water system by total growth projected to occur in that water system.
7. Sum the additional permit-exempt growth by subbasin and add to the initial permit-exempt growth projection.

This alternative permit-exempt growth projection scenario was accepted by the Committee for consumptive use estimation.

The original permit-exempt growth projections were provided to Ecology and the Committee in 2019 (HDR 2019). In 2020, an error in the TRPC results was identified: 116 permit-exempt wells or connections were projected to occur in the Silver Hawk water system service area, when the water system had adequate connections to accommodate all predicted growth. Therefore, these connections were removed from the original projection (Appendix A). These results were organized by subbasin. The WRIA 13 Committee cited this as an example of uncertainty in the assumptions made in the analysis of where new PE wells are expected to occur.

3.0 WRIA 13 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 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 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 (2018 – 2038) (planning horizon).
- 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's Final NEB Guidance defines offset as the anticipated ability of a project or action to counterbalance some amount of the new consumptive water use over the next 20 years (2018-2038). Offsets need to continue beyond the 20-year period for as long as new well pumping continues (Ecology 2019).

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; Ecology 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 impacts from consumptive use on surface water are steady-state, meaning impacts to the stream from pumping groundwater do not change over time. This assumption is based on the wide distribution of future well locations and depths across varying hydrogeological conditions.

Consumptive use of water from projected permit-exempt connection growth was estimated using two different methods; 1) the Irrigated Area Method and 2) the Water System data Method.

3.1 Methods for Indoor and Outdoor Consumptive Use Estimates

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.

3.1.1 Per Capita Indoor Consumptive Use

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

- 60 gallons per day 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 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 (AFY) = 60 gpd x 2.5 people per household x 365 days x 10% CUF

or

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

Where:
HCIWU = Household Consumptive Indoor Water Use (gpd)
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).

3.1.2 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 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 PE domestic wells (Ecology 2018; 2019). HDR estimated the average irrigated lawn area for WRIA 13 by delineating the apparent irrigated area in 80 parcels identified as containing a dwelling unit served by a permit-exempt well in WRIA 13, and averaging them (Appendix B). The irrigated areas were delineated using one technician and a standard method. The average irrigated area per PE connection in WRIA 13 was estimated to be 0.06 acres. The majority of the parcels evaluated did not have an apparent irrigated area (i.e. most parcels had zero irrigated area).

Bias in the irrigated area delineation methods was evaluated by doing a side-by-side comparison study with another consulting form, who was providing similar technical support for the WRIAs 7, 8, and 9 WRE plans (Appendix C). 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 this irrigated area method to specific parcels with meter records (Appendix D). 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 0.06 irrigated acreage average, and because of the large variability in the results (e.g. 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 aces – which would result in a 0.10 acre average irrigated area size.
- HDR completed an irrigated area comparability study (Attachment C) 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 0.09 acre average irrigated area size.
- HDR has completed a statistical analysis of their data, and has determined that using the 95% 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 0.12 acre average irrigated area size.

The Committee decided to move forward with all three of these alternatives as "working numbers". Consumptive use based on all three acreages were evaluated and compared to the consumptive use calculated from the Water System Data Method. Later, the Committee agreed to include the consumptive use estimate based on the 0.10 acre average irrigated area as the "most likely" estimate, and the consumptive use estimate based on the 0.12 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 CU. An average crop irrigation requirement of 16.8 inches per year was estimated for pasture/turf grass from nearby stations as provided in the Washington Irrigation Guide, Appendix B (NRCS-USDA, 1997). Irrigation application efficiency (i.e. the percent of water used that actually reaches the turf) was assumed to be 75%, 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 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)
A = Irrigated Area (acres)
IR = Irrigation Requirement over one irrigation season (feet)
AE = Application efficiency; assumed to be 75% (factor expressed as 1/0.75)
CUF= Consumptive use factor; assumed to be 80% (factor expressed as 0.80)

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

Conversion Factors:

gpm = AFY * 0.61996

cfs = AFY * 0.00138128

This estimate of outdoor consumptive use per household per day is 0.15 AFY (assuming average irrigated area of 0.09 acres), 0.17 AFY (assuming average irrigated area of 0.10 acres) and 0.20 AFY (assuming average irrigated area of 0.12 acres) and can be annualized and converted to acre-feet per year or 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.

4.0 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 WAC 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 bills 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. In WRIA 13, the Thurston PUD provided data for the Prairie Ridge water system from 2007 – 2010, which billed at a flat rate during that time period.

4.1 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.

4.2 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 that used in the Ecology Irrigated Area Method, an 80 percent consumptive factor was applied to determine the consumptive portion of outdoor use.

4.3 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 13, therefore seasonal outdoor water use was assumed to occur over a period of six 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.

5.0 Results

5.1 Permit-Exempt Connection Growth

Initial permit-exempt connection growth is projected to be 2,309 connections (Table 1). The alternative Revised Permit-Exempt Connection Growth scenario is projected to have 307 additional connections, for a total of 2,616 permit-exempt connections. Permit-exempt connection growth is expected to be greatest in the "Deschutes Middle" subbasin. The Revised Permit-Exempt Connection Growth scenario was selected by the Committee for use in consumptive use estimates.

Table 1. WRIA 13 Alternative Growth Projection Scenarios.

Subbasin	Initial Growth Estimate	Revised Growth Estimate Including Water System Service Areas
Boston Harbor	236	296
Cooper Point	171	232
Deschutes Lower	341	379
Deschutes Middle	715	734
Deschutes Upper	29	30
Johnson Point	412	520
McLane	163	165
Spurgeon Creek	88	92
Woodland Creek	154	168
Totals	2309	2616

5.2 Consumptive Use

The WRIA-wide consumptive use estimates using the Irrigated area method were 0.55 cfs (average irrigated area of 0.09 acres), 0.60 cfs (average irrigated area of 0.10 acres), and 0.71 cfs (average irrigated area of 0.12 acres) (Tables 2- 4).

The water system data analysis for WRIA 13 was conducted using consumption data averaged between years 2007 – 2010 from the Prairie Ridge Water System, managed by the Thurston PUD. Consumptive use was projected to be 0.64 cfs (Tables 2 - 4). The Prairie Ridge Water System charges a flat rate for water service and services homes with large lawns that customers heavily irrigate. While some households on permit-exempt connections may exhibit this type of behavior, several members of the Committee have expressed concern that this may not be representative of the "average" household on a permit-exempt connection.

Estimates of consumptive use using the Irrigated Area method are greater than or less than the water system data estimates, depending on the assumed average irrigated area. The Committee selected the irrigated area method for a consumptive use estimate.

Table 2. Annualized Average Outdoor Consumptive Use Estimates for WRIA 13 (20 year planning horizon) – 0.09 acres average irrigated area (correction factor).[75]

Subbasin	Projected No. Permit-exempt Connection	Annual Consumptive Use: Water System Estimate			Annual Consumptive Use: Irrigated Area Estimate (per Ecology Guidance)		
		AFY	GPM	CFS	AFY	GPM	CFS
Boston Harbor	296	52	32	0.07	45	28	0.06
Cooper Point	232	41	25	0.06	35	22	0.05
Deschutes Lower	379	67	41	0.09	57	36	0.08
Deschutes Middle	734	129	80	0.18	111	69	0.15
Deschutes Upper	30	5	3	0.01	5	3	0.01
Johnson Point	520	92	57	0.13	79	49	0.11
McLane	165	29	18	0.04	25	15	0.03
Spurgeon Creek	92	16	10	0.02	14	9	0.02
Woodland Creek	168	30	18	0.04	25	16	0.04
Totals	2616	461	286	0.64	396	245	0.55

[75] Outdoor consumptive water use estimates were rounded to the nearest whole number.

Table 3. Annualized Average Outdoor Consumptive Use Estimates for WRIA 13 (20 year planning horizon) – 0.10 acres average irrigated area (minimum detection value of 0.05 irrigated acres).[76]

Subbasin	Projected No. Permit-exempt Connection	Annual Consumptive Use: Water System Estimate			Annual Consumptive Use: Irrigated Area Estimate (per Ecology Guidance)		
		AFY	GPM	CFS	AFY	GPM	CFS
Boston Harbor	296	52	32	0.07	49	30	0.07
Cooper Point	232	41	25	0.06	39	24	0.05
Deschutes Lower	379	67	41	0.09	63	39	0.09
Deschutes Middle	734	129	80	0.18	122	76	0.17
Deschutes Upper	30	5	3	0.01	5	3	0.01
Johnson Point	520	92	57	0.13	86	54	0.12
McLane	165	29	18	0.04	27	17	0.04
Spurgeon Creek	92	16	10	0.02	15	9	0.02
Woodland Creek	168	30	18	0.04	28	17	0.04
Totals	2616	461	286	0.64	435	269	0.60

[76] Outdoor consumptive water use estimates were rounded to the nearest whole number.

Table 4. Annualized Average Outdoor Consumptive Use Estimates for WRIA 13 (20 year planning horizon) – 0.12 acres average irrigated area 95% Upper Confidence Limit).[77]

Subbasin	Projected No. Permit-exempt Connection	Annual Consumptive Use: Water System Estimate			Annual Consumptive Use: Irrigated Area Estimate (per Ecology Guidance)		
		AFY	GPM	CFS	AFY	GPM	CFS
Boston Harbor	296	52	32	0.07	58	36	0.08
Cooper Point	232	41	25	0.06	45	28	0.06
Deschutes Lower	379	67	41	0.09	74	46	0.10
Deschutes Middle	734	129	80	0.18	144	89	0.20
Deschutes Upper	30	5	3	0.01	6	4	0.01
Johnson Point	520	92	57	0.13	102	63	0.14
McLane	165	29	18	0.04	32	20	0.04
Spurgeon Creek	92	16	10	0.02	18	11	0.02
Woodland Creek	168	30	18	0.04	33	20	0.05
Totals	2616	461	286	0.64	513	318	0.71

[77] Outdoor consumptive water use estimates were rounded to the nearest whole number.

6.0 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 consumptive use scenario (Table 5 - 7). The month of July has the highest irrigation requirement, resulting in the highest monthly consumptive use impact. This information may be used when evaluating projects designed to offset subbasin- and season-specific impacts.

Table 5: WRIA 13 Monthly Outdoor Consumptive Water Use- 0.09 acres average irrigated area (correction factor)

Subbasin	Projected No. Permit-exempt Connections	Consumptive Use by Month (cfs)											
		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Boston Harbor	296	0.0028	0.0028	0.0028	0.0243	0.0956	0.1390	0.1983	0.1385	0.0764	0.0028	0.0028	0.0028
Cooper Point	232	0.0022	0.0022	0.0022	0.0190	0.0749	0.1089	0.1555	0.1086	0.0598	0.0022	0.0022	0.0022
Deschutes Lower	379	0.0035	0.0035	0.0035	0.0311	0.1224	0.1779	0.2539	0.1774	0.0978	0.0035	0.0035	0.0035
Deschutes Middle	734	0.0068	0.0068	0.0068	0.0603	0.2371	0.3446	0.4918	0.3435	0.1893	0.0068	0.0068	0.0068
Deschutes Upper	30	0.0003	0.0003	0.0003	0.0025	0.0097	0.0141	0.0201	0.0140	0.0077	0.0003	0.0003	0.0003
Johnson Point	520	0.0048	0.0048	0.0048	0.0427	0.1680	0.2441	0.3484	0.2433	0.1341	0.0048	0.0048	0.0048
McLane	165	0.0015	0.0015	0.0015	0.0135	0.0533	0.0775	0.1106	0.0772	0.0426	0.0015	0.0015	0.0015
Spurgeon Creek	92	0.0009	0.0009	0.0009	0.0076	0.0297	0.0432	0.0616	0.0431	0.0237	0.0009	0.0009	0.0009
Woodland Creek	168	0.0016	0.0016	0.0016	0.0138	0.0543	0.0789	0.1126	0.0786	0.0433	0.0016	0.0016	0.0016
Totals	**2,616**	**0.02**	**0.02**	**0.02**	**0.21**	**0.85**	**1.23**	**1.75**	**1.22**	**0.67**	**0.02**	**0.02**	**0.02**

Table 6: WRIA 13 Monthly Outdoor Consumptive Water Use – 0.10 acres average irrigated area (minimum detection value of 0.05 irrigated acres)

Subbasin	Projected No. Permit-exempt Connections	Consumptive Use by Month (cfs)											
		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Boston Harbor	296	0.0028	0.0028	0.0028	0.0267	0.1059	0.1541	0.2201	0.1536	0.0845	0.0028	0.0028	0.0028
Cooper Point	232	0.0022	0.0022	0.0022	0.0209	0.0830	0.1208	0.1725	0.1204	0.0663	0.0022	0.0022	0.0022
Deschutes Lower	379	0.0035	0.0035	0.0035	0.0342	0.1357	0.1973	0.2818	0.1967	0.1082	0.0035	0.0035	0.0035
Deschutes Middle	734	0.0068	0.0068	0.0068	0.0662	0.2627	0.3822	0.5457	0.3809	0.2096	0.0068	0.0068	0.0068
Deschutes Upper	30	0.0003	0.0003	0.0003	0.0027	0.0107	0.0156	0.0223	0.0156	0.0086	0.0003	0.0003	0.0003
Johnson Point	520	0.0048	0.0048	0.0048	0.0469	0.1861	0.2707	0.3866	0.2698	0.1485	0.0048	0.0048	0.0048
McLane	165	0.0015	0.0015	0.0015	0.0149	0.0591	0.0859	0.1227	0.0856	0.0471	0.0015	0.0015	0.0015
Spurgeon Creek	92	0.0009	0.0009	0.0009	0.0083	0.0329	0.0479	0.0684	0.0477	0.0263	0.0009	0.0009	0.0009
Woodland Creek	168	0.0016	0.0016	0.0016	0.0152	0.0601	0.0875	0.1249	0.0872	0.0480	0.0016	0.0016	0.0016
Totals	**2,616**	**0.02**	**0.02**	**0.02**	**0.24**	**0.94**	**1.36**	**1.94**	**1.36**	**0.75**	**0.02**	**0.02**	**0.02**

Table 7: WRIA 13 Monthly Outdoor Consumptive Water Use - – 0.12 acres average irrigated area 95% Upper Confidence Limit)

Subbasin	Projected No. Permit-exempt Connections	Consumptive Use by Month (cfs)											
		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Boston Harbor	296	0.0028	0.0028	0.0028	0.0315	0.1266	0.1844	0.2635	0.1838	0.1009	0.0028	0.0028	0.0028
Cooper Point	232	0.0022	0.0022	0.0022	0.0247	0.0992	0.1445	0.2065	0.1440	0.0791	0.0022	0.0022	0.0022
Deschutes Lower	379	0.0035	0.0035	0.0035	0.0403	0.1621	0.2361	0.3374	0.2353	0.1292	0.0035	0.0035	0.0035
Deschutes Middle	734	0.0068	0.0068	0.0068	0.0781	0.3139	0.4572	0.6535	0.4557	0.2502	0.0068	0.0068	0.0068
Deschutes Upper	30	0.0003	0.0003	0.0003	0.0032	0.0128	0.0187	0.0267	0.0186	0.0102	0.0003	0.0003	0.0003
Johnson Point	520	0.0048	0.0048	0.0048	0.0553	0.2224	0.3239	0.4630	0.3228	0.1772	0.0048	0.0048	0.0048
McLane	165	0.0015	0.0015	0.0015	0.0176	0.0706	0.1028	0.1469	0.1024	0.0562	0.0015	0.0015	0.0015
Spurgeon Creek	92	0.0009	0.0009	0.0009	0.0098	0.0393	0.0573	0.0819	0.0571	0.0314	0.0009	0.0009	0.0009
Woodland Creek	168	0.0016	0.0016	0.0016	0.0179	0.0718	0.1047	0.1496	0.1043	0.0573	0.0016	0.0016	0.0016
Totals	**2,616**	**0.02**	**0.02**	**0.02**	**0.28**	**1.12**	**1.63**	**2.33**	**1.62**	**0.89**	**0.02**	**0.02**	**0.02**

7.0 References

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

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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) over $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 Google Earth .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 Google Earth 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 ADUs under construction in the most recent Google Earth imagery were excluded from the analysis, and an alternate parcel was evaluated.

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

Figure B-1. No irrigated areas visible in most recent google earth 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 vegetation 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). Average irrigated acreage was 0.15 acres (Table B-1). In all WRIAs evaluated, most of the 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% upper confidence limit of the mean could only be fit with a non-parametric distribution and was about two times the quantity of the calculated arithmetic mean.

Figure B-5. Parcels selected in WRIA 13 with existing PE connections that were delineated for apparent irrigated areas.

Table B-1. Irrigated acreage delineation results.

Statistic	WRIA 13
PE Parcel Sample Pool	7,271
Sample Size	80
Mean (acres)	0.06
Mean with 0.05 minimum acreage (acres)	0.10
Standard Deviation (acres)	0.12
95% UCL (acres)	0.12

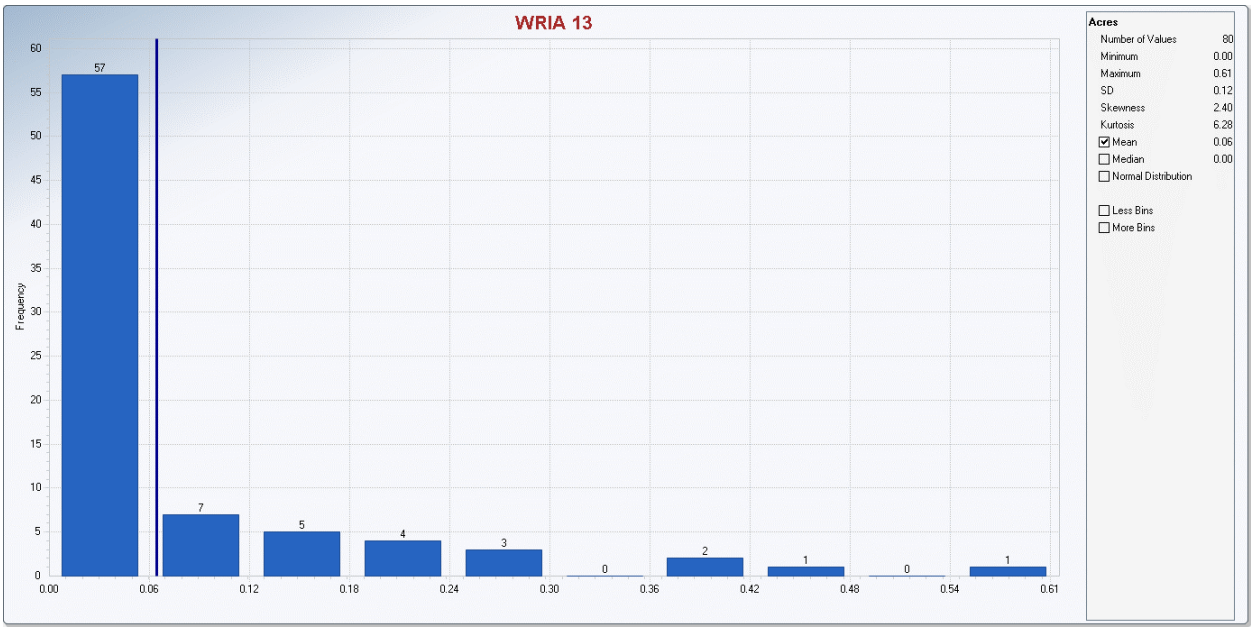

Figure 2. Histogram of WRIA 13 irrigated acreage delineation results

Attachment C

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 13 contains the results of the corroboration analysis.

Table 13: 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 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.