

WATER WITHDRAWAL STUDY

Water Resource Inventory Area 48

Twisp, Washington

Prepared for: Methow Watershed Council

Project No. 080180-003 • May 10, 2011 DRAFT

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Introduction

The Instream Flow Rule (Rule) for the Methow River was established in 1976 as Chapter 173-548 of the Washington Administrative Code (WAC). The Rule established a reservation of 2 cubic feet per second (cfs) of water in each of seven reaches of the Methow River watershed for future single domestic and stock water uses (Figure 1). The 2 cfs reservation in each reach is expressed as a reduction in streamflow associated with the consumptive use of aggregate instantaneous withdrawals authorized under the Rule.

Developing estimates of total and consumptive use (total withdrawal minus return flow) of water to quantify the unallocated portion of the reservation is a high priority issue identified in the *Methow Basin (WRIA 48) Watershed Plan* (Methow Basin Planning Unit, 2005) and the *Final Detailed Implementation Plan* (Methow Watershed Council, 2009). As part of Phase 4 (Watershed Plan Implementation) of the watershed planning process, the Methow Watershed Council (MWC) directed Aspect Consulting, LLC (Aspect Consulting) to provide recommendations for quantifying the consumptive use of single domestic homes on water right permit-exempt wells (exempt wells) in the basin for tracking allocation against the established reserve and support a revision of the Rule. Aspect Consulting previously prepared the *Water Withdrawal Study Plan* (Aspect, 2009), describing the general approach followed in this report, and the *Background Information and Recommendations for Evaluating Consumptive Water Use* (Aspect, 2010), providing the basis for determining the consumptive portion of indoor and outdoor water uses.

This report presents the data, evaluation, and results of the water withdrawal study to estimate total and consumptive single domestic and stock water use by exempt wells in the Methow Watershed. Water use estimates are presented on an annual average basis and for the peak month of use. The month with the highest consumptive use is of primary interest for the purposes of evaluating potential debits to the Chapter 173-548 WAC surface water reservations, as this will define the upper limit on the number of potential future exempt well uses that could be accommodated under the reservations.

To best support a revision of the Rule, the water use estimate should meet the following objectives:

- Be defensible and accepted by the Washington State Department of Ecology (Ecology).
- Be applicable to lots served by exempt wells (both developed and future developable).
- Allow for identification of the timing (season or month) and magnitude of maximum average use and maximum impacts to surface water flows.
- Account for potential year-round use (i.e., assume all are primary residences) even where occupation is currently seasonal.
- Be representative of conditions in WRIA 48.

- Ideally produce a single value that represents peak exempt well water use and resultant impacts to surface water flows in WRIA 48.
- Include estimates of both indoor and outdoor use.

The remainder of this report is organized as follows:

- **Summary and Results of Water Use Study** summarizes results of the water use study and presents recommended annual average and maximum month total and consumptive water use rates for use in tracking water use under the reservation;
- **Other Estimates of Domestic Water Use in Washington State** presents an overview of other published evaluations of domestic water use in the state, including evaluations of indoor, outdoor, total and consumptive uses.
- **Evaluation of Public Water System Data** describes water system data collected for this study and the indoor and outdoor water use rates estimated based on these data;
- **Outdoor Irrigation Use by Exempt Wells** provides an aerial photograph analysis of the average acreage irrigated by exempt wells in the watershed and presents estimates of associated total and consumptive water use;
- **Stock Water Use** presents an update of the estimated stockwater use from the *Methow Basin (WRIA 48) Watershed Plan*, including estimated average annual and maximum month total and consumptive water use.

Summary and Results of Water Use Study

Based on the objectives of the water use study and the analyses presented below, we recommend using a single value for peak month consumptive use of 710 gallons per day (gpd) per residence served by an exempt well for administering the reservation. The largest component of total and consumptive water use is outdoor irrigation, followed by indoor water uses, and then stock water. The outdoor irrigation component is dependent on the extent of the irrigated area and climatic conditions where the water is used. Review of climatic data (temperature and precipitation) for the developable areas of the watershed indicate that, on average, each of the reaches is climatically similar to the other reaches in the areas where development on exempt wells has and will occur and, assuming equal irrigated area, would have similar outdoor water uses. Although there is likely considerable variation in individual exempt well use, the use of a single value is justified when considering the averaging effect of a number of exempt wells geographically distributed through the watershed.

Because exempt wells are not required to be metered, total water use was estimated by alternate methods, including evaluating meter data from public water systems and an aerial photograph analysis of the extent of irrigation. Consumptive water use was estimated based on the estimated total indoor, irrigation, and stock water use components;

consumptive use factors expressed as a percentage of indoor and stock water use; and published irrigation consumptive use rates for pasture and turf in the Methow Watershed.

Indoor water use was estimated based on review of winter residential water service meter data from the City of Pateros, Town of Twisp, and Town of Winthrop Group A water systems and supplemented by source meter data provided by the Edelweiss Group A water system. Group B water systems within the watershed either do not have meters installed or do not record meter readings. Efforts were made to obtain water use data from Group B systems located outside the watershed in areas with similar climatic conditions; however, as with the in-watershed systems contacted either did not have suitable data or were unwilling to provide data.

Irrigation water use for residences served by exempt wells was estimated using two approaches. The first approach was based on review of monthly summer residential water service meter data from the Group A water systems. The estimated indoor water use was subtracted from the average maximum month water use to estimate peak residential irrigation use. The second approach was based on an aerial photograph analysis of irrigated areas on currently developed parcels. The aerial photograph analysis was limited to parcels apparently served by exempt wells and with no other known source of irrigation water. Over the entire watershed about 0.08 acres is irrigated at the average parcel served entirely by exempt well. A value of 0.10 acres was used for the outdoor water use estimate in order to provide a level of conservatism and because that value is consistent with the average irrigated area in the Lower Methow reach, where the largest number of potentially developable parcels are located. Monthly total and consumptive irrigation requirements for a 0.10-acre plot of pasture or turf were calculated using published irrigation requirements based on climatic data from Winthrop. The maximum monthly total and consumptive use is expected to occur during July. Estimated irrigation use based on the water system data and aerial photograph analysis compared favorably with each other.

Stock water use was evaluated based on a previous evaluation presented in Appendix E of the *Methow Basin (WRIA 48) Watershed Plan* (Methow Basin Planning Unit, 2005), review of agricultural census data for Okanogan County, and water use requirements for horses and cattle. Based on these data, there is currently an average of less than one head of livestock per developed parcel in the watershed. It is likely that a significant portion of the total livestock in the watershed is associated with a handful of landowners raising multiple head for commercial purposes. Future development of parcels relying on exempt wells is expected to be primarily for residential rather than agricultural uses, such that the average number of livestock per parcel would be expected to decrease over time. As a conservative assumption, an average of one head of livestock was assumed to be associated with each exempt well use.

Based on these evaluations, we recommend using the following values for establishing total water use associated with a single parcel served by an exempt well:

- Indoor use of 200 gpd, year round.
- Maximum month outdoor water use to irrigate 0.10 acres of about 760 gpd occurring in July. On an annual basis, the average total outdoor use rate is about 185 gpd.
- Summer season stock water use of 30 gpd, with an annual average use of 15 gpd.

Combined, these values result in a maximum month total water withdrawal rate of about 1,000 gpd per exempt well connection, with an annual average rate of about 400 gpd. These total use rates are consistent with data from the Group A water systems, which averaged between the different systems show a maximum month use of about 1,090 gpd and an average annual use of about 450 gpd. These compare to the estimated annual average and maximum month and residential total water use rates of about 600 gpd and 1,200 gpd, respectively, presented in the *Methow Basin (WRIA 48) Watershed Plan* (Methow Basin Planning Unit, 2005).

Only a portion of the total water withdrawn is consumptively used; the remainder will return to the groundwater system via septic or irrigation return flows. In establishing water withdrawal impacts to surface water flows in the Methow River only the consumptive quantity should be considered. We recommend using the following values for establishing typical consumptive water use associated with a single parcel served by an exempt well:

- Applying a consumptive use factor of 15 percent to total indoor use as recommended in the *Background Information and Recommendations for Evaluating Consumptive Water Use* (Aspect, 2010), consumptive use for indoor residential purposes is about 30 gpd, year round.
- Using the published pasture and turf irrigation requirements for Winthrop, the maximum month consumptive use for irrigation of 0.10 acres is about 650 gpd in July. On an annual basis, the average consumptive use rate for outdoor irrigation is about 160 gpd.
- Assuming stock water use is entirely consumptive, the maximum month and average annual stock water consumptive uses are 30 and 15 gpd, respectively.

Combined, these values result in a maximum month (July) consumptive water use rate of about 710 gpd per residence served by an exempt well. The average annual consumptive use is about 205 gpd.

Other Estimates of Domestic Water Use in Washington State

Estimates of domestic water use are available from a variety of sources and are summarized in Table 1. Most of the estimates combine indoor and outdoor use as a single value. The estimates are also primarily for average day demand (ADD), which represents the average year-round use on a daily basis and does not reflect seasonal peak use that are of interest for this study. Exceptions are noted in the table.

In general these estimates are not directly applicable to WRIA 48, due to different climatic conditions and resulting outdoor water uses; however, they do provide some context for evaluating the water use analyses presented in this report.

The *Methow Basin (WRIA 48) Watershed Plan* (Methow Basin Planning Unit, 2005) includes residential water use data based on Town of Twisp metering record from the year 2000 of 598 gpd (ADD) with a maximum day demand (MDD) of 1,189 gpd. These estimates included commercial uses (e.g., restaurants, businesses, pools) in the residential water use estimates. The inclusion of non-residential uses likely overestimates residential water use.

Highlands Associates (1993) provided a summary of several water use estimates, including an estimate of 220 gallons per day (gpd) to 260 gpd, based on Town of Twisp water use data. Other estimates provided by Highland Associates include an estimate for indoor water use of 185 gpd by the United States Department of Housing and Urban Development for the Methow, an estimate of 360 gpd (ADD) by the American Water Works Association for the entire nation, and an estimate of 403 gpd (ADD) by the Washington Rural Water Association for Washington State.

Water use estimates from watershed plans for other WRIsAs in eastern Washington are also summarized in Table 1. These estimates of total water use range from 367 gpd to 980 gpd. All of these estimates represent total water use, combining indoor and outdoor uses as a single value. With the exception of the Wenatchee Watershed, these estimates are for ADD and generally did not account for seasonality or attempt to estimate peak water use. The Wenatchee Watershed Plan provides an ADD of 380 gpd and an MDD of 950 gpd.

Estimates of water use are also included in Ecology's rule making for water management and instream flows for a number of WRIsAs. As shown in Table 1, combined indoor and outdoor water use estimates range from 175 to 250 gpd assuming on-site septic systems (OSS). For residences with OSS, the Quilcene-Snow water management rule provides an indoor consumptive use of 13 gpd and a combined indoor and outdoor use of 250 gpd. WRIsAs 25 through 28 assume water usage of 240 gpd for residences with OSS and 800 gpd for residences without OSS. The reason for this large increase is not known. All of these estimates appear to reflect average daily use rather than peak water use.

The Washington Department of Health (WDOH) *Water System Design Manual* (WDOH, 2009) provides estimates of water use, including a statewide ADD of 200 gpd (indoor), a statewide MDD of 350 gpd (indoor), and a MDD of 1,500 gpd for eastern Washington.

Evaluation of Public Water System Data

Exempt wells are not required to be metered; therefore, public water system data were reviewed as an alternate approach to estimate exempt well uses. Residential water use data were requested from public water systems throughout WRIA 48, as well as select water systems located outside the WRIA for use in evaluating indoor and outdoor water uses. Public water systems are classified as either Group A or Group B water systems. Group A water systems are those that provide service to 15 or more service connections or regularly serve 25 or more people. Group B water systems are those that provide service to fewer than 15 connections and fewer than 25 people per day. Group A water systems are further classified as community and noncommunity water systems. Community water systems are those that provide service to a year-round (180 or more days per year) residential population (e.g., municipalities, private housing developments), while noncommunity water systems provide service to nonresidential populations (e.g., schools, motels, campgrounds).

For the Group A water systems, this evaluation was limited to data from community water systems serving year-round residential populations. Group A community water systems with primarily part-time service connections and noncommunity systems that do not serve permanent residential populations were not included in this evaluation.

Group B water systems with seven or more residential connections were also selected for inclusion in this evaluation, based on the assumption that they would be the most likely Group B systems to have some form of water metering data. However, as discussed below managers of the Group B systems that were successfully contacted either did not have meters installed or did not have meter readings available.

Managers of select Group B water systems located outside of WRIA 48 were also contacted. Similar to the in-WRIA systems, these systems did not have meters or did not maintain meter readings. One manager of four Group A systems (Chelan County PUD) did provide summary information on water use.

Group A Water System Data and Evaluation

There are 32 active Group A water systems located in WRIA 48. Of the active Group A water systems, eight are classified as community water systems (Table 2), and the remaining are noncommunity systems. Water use data were acquired from the four largest community water systems in WRIA 48 (City of Pateros, Town of Twisp, Town of Winthrop, and Edelweiss). Attempts were made to contact the managers for the Alta Lake Golf Course Plat and the Methow Water System using the contact information on file with WDOH; however, these effort were unsuccessful. The Pine Forest Water System was not included in this evaluation because, based on water system information from

WDOH, less than 20 percent of the connections appear to be full-time residences. Water use data were requested from the Wolf Creek Property Owners Association, but the association elected not to provide data.

The City of Pateros, Town of Twisp, and Town of Winthrop provided meter data for individual residential service connections within their respective service areas. The Edelweiss water system provided source meter data for their two well sources, but did not have individual residential service meter data. Service connection or source meter data were generally available on a monthly basis, except that the City of Pateros and Town of Winthrop do not collect meter readings over the winter (generally between November and April). Cumulative winter use for these water systems are reflected in the first meter reading of the spring. Winter water use rates were obtained by dividing the total water use by the number of days between the last fall meter reading and the first spring reading.

Full-Time Versus Part-Time Connections

Water use data in this evaluation were limited to full-time, year-round, single-family residential connections. Nonresidential, multi-family residential, or apparent part-time connections were not included, as they are not considered representative of year-round single-domestic exempt well use.

Monthly and winter meter records for each connection served by City of Pateros, Town of Twisp, and Town of Winthrop were reviewed to identify those connections that appear to be full-time, year-round residential uses versus those that appear to be only seasonal or part-time uses. Meter records representing full-time use were defined as those with no more than one reporting period (monthly or winter, depending on the data available) with average use of less than 50 gpd. The 50 gpd threshold was selected as the minimum expected single-occupancy use based on information in the Department of Health *Water System Design Manual*. In evaluating water system demand for systems with both full- and part-time residences, Section 5.3.3 of the *Water System Design Manual* indicates that when water use for a residence falls significantly below a range of 54 to 64 gpd per capita, residents probably occupy the dwelling intermittently. Water meter records that did not meet these criteria were not included in the evaluation of residential water use.

The Edelweiss water system provided monthly source meter data for their two wells, but did not have individual residential service meter data. The system manager indicated that one well serves one full-time residence and one part-time residence, along with a campground and public restroom and showers. Because of the significant non-residential uses of this well, these meter data were not evaluated. The second source well serves 51 full-time and 117 part-time residences and is also used to fill a community swimming pool. The Water Facility Inventory (WFI) form for the Edelweiss water system on file with Department of Health was reviewed to estimate the number of part-time residences expected to be occupied at any one time. The WFI indicated that the 51 full-time connections serve a population of 95 people, or about 1.9 people per connection. The WFI also indicates an average part-time population of about 39 people. Dividing the average part-time population (39 people) by the average number of people per full-time connection (1.9) results in an about 20 equivalent full-time connections. Combining the

full-time connections (51) with the full-time equivalent part-time connections (20), results in a total of 71 equivalent full-time connections.

Water Use Evaluation

Water use data were reviewed to determine average daily use per full-time residential connection on an annual basis and over each metering period (monthly or winter, depending on meter reading frequency) for the four Group A water systems. Water use during the winter months, when outdoor water use is assumed to be minimal, was used to estimate year-round indoor use. Water use over the summer months that exceed the indoor use is assumed to reflect outdoor uses, primarily for irrigation of lawns, landscaping, and gardens.

Table 3 summarizes the estimated average daily winter water use (indoor), maximum month average daily water use (indoor and outdoor), and annual average daily use (indoor and outdoor) for the City of Pateros, Town of Twisp, and Town of Winthrop water systems. Table 4 summarizes these data for the Edelweiss water system. Estimated indoor water use ranges from 134 gpd per full-time connection in the Town of Twisp to 229 gpd per full-time connection in the Town of Winthrop, with an average among the four water systems of 198 gpd per full-time connection.

Summer maximum month use ranges from 673 gpd per full-time connection in the Town of Twisp to 1,425 gpd per full-time connection in the City of Pateros, with an average among the four water systems of 1,086 gpd per full-time connection.

Table 5 presents a summary of the average and median residential parcel size, average precipitation, and average maximum daily temperature in July for each of the municipal water system service areas. The average and median parcel sizes are generally similar between the systems, and differences in average parcel size do not positively correlate with differences in outdoor water use between the systems. Differences in climatic conditions between the three municipalities show some relationship to maximum month water use, with the higher use City of Pateros system having the lowest precipitation and highest summer temperatures. However, differences between maximum month water use by the Town of Twisp and Town of Winthrop do not appear to be related to climatic differences.

The following sections provide additional information on the evaluation of water use data from the City of Pateros, Town of Twisp, Town of Winthrop, and Edelweiss water systems.

City of Pateros

The Pateros Water System service area lies mostly outside of WRIA 48; however, this system was included in the water use evaluation because it does lie partially within the WRIA and represents the largest data set available for the Lower Methow reach. Monthly residential water meter data were provided for April 2010 through October 2010. Meter readings from March 2011, measuring winter use starting the previous November, were also provided. A summary of average annual residential use was also provided for 2007

through 2009; the 2007 through 2009 data indicated annual average use of 570 to 620 gpd per connection.

As shown on Table 3, in 2010 there were a total of 249 active residential connections, of which 137 met the criteria for full-time use. Average annual use of those 137 connections was 577 gpd per connection, which is consistent with the average annual use from 2007 through 2009. Average indoor (winter) use from November 2010 to March 2011 was 195 gpd per connection and maximum month summer use was 1,425 gpd in August.

Town of Twisp

Monthly residential water meter data were provided for March 2007 through 2010, except for November 2009 through March 2010 when no meter readings were performed. For the November 2009 through March 2010 period, daily water use was calculated by dividing the March meter reading by the number of days since the November meter reading. Over that period there was an average of 355 active residential connections, of which an average of 263 met the criteria for full-time use.

As shown on Table 3, average annual use ranged from 214 to 275 gpd per full-time connection, with an average over the period reviewed of 252 gpd. Indoor use varied little from year to year, with an average of 134 gpd per full-time connection. The maximum month use occurred in July each year and ranged from 547 to 795 gpd, with an average over the four year period of 673 gpd.

These estimates are lower than a previous estimate of residential water use based on Town of Twisp data presented in the *Methow Basin (WRIA 48) Watershed Plan*. The previous estimate, using data from the year 2000, indicated average use of about 600 gpd and peak use of about 1,200 gpd per residential connection. This discrepancy is due to several factors, including water system improvements (leak detection and repair), improved metering, and changes to the rate schedule that have resulted in a significant reduction in total water use by the Town of Twisp. Additionally, the previous estimate included commercial uses (e.g., restaurants, businesses, pools) as residential water use, likely biasing the estimate high.

Town of Winthrop

Monthly residential water meter data were provided for April 2006 through November 2010, except for the winter when the meters were not read. Over that period there was an average of 190 active residential connections, of which 110 met the criteria for full-time use.

As shown on Table 3, average annual use ranged from 386 to 466 gpd per full-time connection, with an average over the period reviewed of 420 gpd. Indoor use varied from 162 to 264 gpd per full-time connection, with an average over the period reviewed of 229 gpd. The maximum month use occurred in August each year and ranged from 924 to 1,016 gpd, with an average over the 5-year period of 967 gpd.

Edelweiss

Monthly groundwater well source meter data were evaluated for the period November 2005 through October 2010. As discussed above, there are 51 full-time residences and 117 part-time residences served by the Edelweiss water system's main well. Based on information on the part-time population served by the Edelweiss water system the part-time connections are equivalent to about 20 full-time connections, resulting in a total of 74 full-time or full-time equivalent connections.

Evaluation of the Edelweiss water system data were further complicated by significant leaks that were detected in February and December 2008. For this reason, the winter 2007/2008, average annual 2008, and winter 2008/2009 data are not considered valid in evaluating residential use from this water system, although these data are shown on Table 4. Due to these limitations in the source meter data and uncertainties about the level of part-time occupancy, average residential water use data from the Edelweiss system should be considered an approximation.

Average annual use (excluding the 2008 and 2009 data) ranged from 525 to 583 gpd per full-time connection, with an average over the period reviewed of 546 gpd. Indoor use ranged from 208 to 246 gpd per full-time connection, with an average over the period reviewed of 232 gpd. The maximum month use occurred in either July or August each year and ranged from 1,186 to 1,416 gpd, with an average over the five year period of 1,281 gpd.

Group A Water Systems outside WRIA 48

One satellite management agency, Chelan County PUD, provided average annual water use data for four small Group A water systems in Chelan County. These water systems (Chelan Ridge, Chelan Falls, Ollala Canyon, and Dryden) are located south of WRIA 48 near the Cities of Chelan and Cashmere. On average, these systems experience somewhat drier summers than the average for WRIA 48, but were considered in this evaluation as representing smaller (less than 150 connections) Group A water systems.

The Chelan Ridge water system serves 40 residential connections for indoor and outdoor water uses. For the period 2002 to 2007, this system had an annual average daily water use of 360 to 405 gpd per connection.

The Chelan Falls water system serves 140 to 150 residential connections for indoor and outdoor water uses. For the period 2002 to 2007, this system had an annual average daily water use of 455 to 625 gpd per connection.

The Dryden and Ollala Canyon water systems serve 27 and 104 residential connections, respectively. These systems receive water for outdoor irrigation from a separate source than the indoor domestic uses. For the period 2002 to 2007, the Dryden water system had an annual average daily water use of 245 to 300 gpd per connection and the Ollala Canyon water system had an annual average daily water use of 240 to 270 gpd per connection.

Group B Water Systems

There are 139 active Group B water systems located within WRIA 48. Based on information from the Department of Health, 111 of the Group B water systems have six or fewer service connections. It was assumed that these systems are likely served by exempt wells and would not have metering requirements. Twenty-one of the remaining 28 Group B water systems were identified as being residential. Aspect Consulting and members of the MWC attempted to contact these 21 Group B water systems. Interviews with managers of systems that were successfully contacted indicated that meters either were not installed or are not being read.

Aspect Consulting also contacted several water system satellite management agencies in the region and confirmed that none manage water systems in WRIA 48. Attempts were made to collect water use data from Group B water systems located outside of WRIA 48, with similar climatic conditions as the Methow Watershed. As with the in-watershed Group B systems, those contacted either did not have meters installed or did not record meter readings. As a result, no water use data were obtained from Group B water systems.

Conclusions based on Water System Data

A year-round indoor water use rate of 200 gpd per residence was calculated based on the wintertime water meter data provided by four of the Group A water systems in WRIA 48. Although the Group A water system data from Chelan County PUD potentially indicate higher indoor water use rates, without more detailed monthly or quarterly data from those systems, it is uncertain whether there may be seasonal patterns in water use that would include some outdoor uses.

The *Background Information and Recommendations for Evaluating Consumptive Water Use* (Aspect, 2010) report recommended a consumptive use factor of 15 percent for indoor water use. Applying this factor to the recommended indoor water use rate of 200 gpd results in a year-round consumptive use of 30 gpd per residence served by an exempt well.

Subtracting the indoor use rate of 200 gpd from the maximum month water use of 1,070 gpd per connection indicated by the Group A water system data results in about 870 gpd maximum month water use for outdoor irrigation purposes. As discussed in the following section, this value is generally consistent with the estimated water by exempt wells in WRIA 48 based on review of aerial photographs.

Outdoor Irrigation Use by Exempt Wells

Seasonally, outdoor irrigation water use represents the largest component of the water demand for residential parcels. This section quantifies outdoor irrigation water use for currently developed parcels supplied by exempt wells. Because they are obtained from parcels identified as served by exempt wells, these water use estimates are expected to be

more representative of outdoor water use by exempt wells than the Group A water system data described previously.

The approach consisted of first identifying developed, single-family residential parcels that are self-supplied from an exempt source, and are apparently not known to be receiving irrigation water from a non-exempt source (i.e., irrigation district, ditch company, or private water right). Aerial photographs of these parcels were then reviewed to identify whether outdoor irrigation was occurring and determine the irrigated area.

Evaluation of Average Irrigated Area

The *Instream Flow Reservation Tracking Database* (Aspect, 2011) developed to assist in tracking allocation of the water reservations under the Instream Flow Rule was used to randomly select 245 parcels, or about 10 percent of the developed parcels meeting the above criteria. Thirty-five of the randomly selected parcels were rejected from the analysis for one of the following reasons:

- It was not possible to determine if the parcel was irrigated, due to poor aerial photograph quality or heavy tree cover, or
- The irrigated area, either entirely within the parcel or contiguous with adjacent irrigated fields, was well in excess of the 0.5-acre limit for exempt well use, indicating the parcel was potentially receiving irrigation water from some non-exempt source. Several parcels with irrigated areas greater than 0.5 acres, but that were not part of a larger irrigated field were retained in this analysis, but with the measured irrigated area limited to the 0.5 acres allowed for exempt well uses.

Locations of the 210 parcels retained for this analysis are shown on Figure 2. The number of parcels evaluated per reach and the average irrigated areas are summarized on Table 6. Copies of the aerial photographs reviewed for this evaluation, including the delineated irrigated areas are provided in Appendix A.

Over the entire watershed, about one-third of parcels evaluated appear to be irrigated to some degree, with an average irrigated area of about 0.08 acres. The smallest average irrigated areas are in the Headwaters (0.03 acres) and Upper Methow (0.04 acres) reaches, and the largest average irrigated areas are in the Middle Methow (0.09 acres) and Lower Methow (0.10 acres) reaches.

An average irrigated area of 0.10 acres was used for determining exempt well irrigation water use (see below). Although greater than the watershed-wide average irrigated area of 0.08 acres, this value was deemed appropriate for two reasons. First, 0.10 acres is the average irrigated area in the Lower Methow reach, where the largest number of potentially developable parcels are located and by extension where the greatest amount of future exempt well use is likely to occur. Second, there are uncertainties inherent in both estimating current irrigated areas and in applying those estimates to potential future development; use of a value at the high end of the range of irrigated areas is a conservative assumption that provides some additional confidence that the estimated irrigation water use will be at least as high as actual future uses.

Determination of Irrigation Water Use

Irrigation water use was calculated based on the irrigated acreage discussed above and monthly crop irrigation requirements representative of the watershed. The following sections discuss selection of crop irrigation requirements and calculated exempt well irrigation water use.

Selection of Crop Irrigation Requirements

Published values of crop irrigation requirements for the Methow Watershed area were reviewed with climate data for the area to select a single set of monthly irrigation values that, on average, are applicable to each of the watershed reaches. The main factors controlling crop irrigation requirements are precipitation and temperature during the growing season, with areas experiencing higher temperature and lower precipitation requiring more irrigation.

Appendix A of the Washington Irrigation Guide (WIG; Natural Resources Conservation Service, 1997) presents crop irrigation requirements based on data from two climate stations in the watershed located at Methow and Winthrop. Table 7 summarizes average monthly precipitation and July and August average maximum daily temperature data from the Methow and Winthrop climate stations for the period 1971 through 2000. Also presented are the average annual and growing season (May through September) precipitation totals.

Also presented on Table 7 are average precipitation and temperature data for each reach for the period 1971 through 2000. These data are taken from the Oregon State University PRISM climate model, which provides monthly temperature and precipitation on an 800 meter grid (PRISM Climate Group, 2011). The gridded PRISM data were spatially averaged over the developable parcels within each reach to produce the average climate data by reach. Figures 3 and 4 present contours of the average annual precipitation and average maximum daily temperatures in July from the PRISM data. As shown on these figures, temperature and precipitation are strongly correlated to elevation in the watershed, with higher precipitation and lower temperatures occurring at higher elevations.

As shown on Table 7, the annual and growing season precipitation totals at the Methow and Winthrop stations are less than the average annual and growing season precipitation for each reach, although values from the Winthrop station are closer to the reach average values. Similarly, the average maximum daily summer temperatures are higher at these stations than the spatially averaged temperatures for each reach, with values from the Winthrop station again closer to the reach average values.

Based on these comparisons of average climate conditions, the crop irrigation requirements from the Winthrop station were selected as being most representative of average climate conditions at developable parcels throughout the watershed. Use of this station will likely overestimate outdoor irrigation requirements for parcels located at higher elevations and underestimate irrigation requirements for parcels located at lower elevations, but on average provides a reasonable estimate for evaluating water use.

Exempt Well Irrigation Water Use

Exempt well outdoor irrigation total and consumptive use were calculated using the crop irrigation requirement from the Winthrop climate station for pasture/turf, assumptions about irrigation methods and efficiencies, and an irrigated area of 0.10 acres. Calculations and results are shown on Table 8.

Average pasture/turf crop irrigation requirements based on the Winthrop station are about 18.61 inches, or about 1.55 acre-feet per year (afy) per acre. The WIG indicates the typical irrigation season extends from early June to early October, with the peak irrigation requirements in July. It is assumed that most irrigation from exempt wells will use some type of sprinkler system (e.g., pop-up impact). Ecology Water Resources Program Guidance 1210 estimates these sprinkler systems to be 60 to 85 percent efficient with an average efficiency of 75 percent. Using the average 75 percent efficiency, the total irrigation requirement is 2.07 afy per acre, or about 0.21 afy to irrigate 0.10 acres. On a monthly basis, the total irrigation requirement ranges from about 40 gpd in early October to about 760 gpd in July. This value is reasonably similar to the peak month outdoor water use of 870 gpd estimated based on Group A water system data discussed previously.

The amount of water that is consumptively used includes the crop evapotranspiration and additional water evaporated during irrigation application. Guidance 1210 recommends an evaporative loss of 10 percent of all irrigation water applied with a sprinkler irrigation system and an average consumptive use of 85 percent of the total irrigation requirement. Using these percentages and the total irrigation requirement results in about 1.76 afy per acre of consumptive use for a total of 0.18 afy of consumptive use over 0.10 acres. The remaining 0.03 afy is return flow; the water that returns to the hydrologic system through infiltration below the plant root zone and/or runoff. On a monthly basis, the consumptive use ranges from about 35 gpd in early October to about 650 gpd in July.

Stock Water Use

Stock water is water used for raising and care of livestock and under the exempt well uses includes water for animal drinking and feeding, washing of animals, and cleaning of animal stalls and equipment used to feed or milk them. It does not include water to grow crops for animal feed or for processing of animals. This section evaluates annual average and peak season total and consumptive use associated with stock watering by exempt wells.

Appendix E of the *Methow Basin (WRIA 48) Watershed Plan* presented an estimate of the average current level of stock water use in the watershed of 0.09 cfs. This was based on an estimated total of 4,000 head of livestock in the watershed and an assumed average use of 15 gpd per head.

The United States Department of Agriculture Agricultural Censuses for 1997, 2002, and 2007 (USDA, 1999; 2004; and 2009) were reviewed to evaluate whether there have been

significant changes in the number of livestock within the watershed since the *Watershed Plan* was produced. Census data on the number of head of livestock are only available on the County level. Table 9 summarizes the number of cattle, hogs, poultry, and ponies and horses in Okanagan County from 1997 to 2007. Overall, total head of livestock showed a decrease since 1997 and remained relatively steady from 2002 to 2007. Based on these trends, and lacking more watershed-specific data, the estimated number of livestock (4,000 head) reported in the *Methow Basin (WRIA 48) Watershed Plan* are considered to remain valid.

Based on the *Instream Flow Reservation Tracking Database* (Aspect, 2011) developed for the MWC there are about 5,700 developed residential parcels in WRIA 48, or an average of less than one head of stock per parcel. It is likely that a significant portion of the total livestock in the watershed is associated with a handful of landowners raising multiple head for commercial agricultural purposes. Future development of parcels relying on exempt wells is expected to be primarily for residential rather than agricultural uses, and the average number of livestock per parcel would be expected to decrease over time. As conservative assumption water use estimated in this evaluation includes water sufficient for an average of one head of stock per exempt well.

The *Water System Design Manual* recommends an annual average water use of 12 gpd per head for horses and steers up to 20 gpd per head for dairy cows and beef yearlings. For this evaluation, average annual use of stock in the watershed is assumed to be 15 gpd per head, consistent with the *Methow Basin (WRIA 48) Watershed Plan* and about the average of the various stock watering requirements. Stock water requirements are higher in the summer, when temperatures are highest. The maximum month stock water use is assumed to be twice the annual average, or 30 gpd per head.

Some water used for stock watering may be returned to groundwater or surface water as return flows. One study of withdrawals and return flows from livestock facilities in Ohio using greater than 100,000 gpd found consumptive use of stock water ranged from 12 to 100 percent of total use, with a median value of 76 percent (USGS, 2009). Details on uses of water at the livestock facilities were not provided in this study, but it appears that the lower range of consumptive use is associated with facilities using large amounts of process water. It is expected that the typical small-scale stock water use in the watershed will be primarily for animal drinking and washing purposes, and that any effluent would not be collected and either treated for surface water discharge or infiltrated to groundwater. As a result, consumptive use of stock water in the watershed would be at the high end of the range. For this evaluation, it was conservatively assumed that all stock water withdrawals are consumptively used.

Based on this information, total and consumptive stock water use per residential parcel is estimated to be 15 gpd on an average annual basis, and a peak of 30 gpd during the summer months.

Water Use Evaluation Uncertainties

The rates of total and consumptive water use documented in this report are based on metered water use from Group A water systems, calculated outdoor water use based on aerial photograph analyses of exempt well irrigation and published irrigation water requirements, and previous estimates of the number of livestock present in the watershed. There are several sources of potential uncertainty or error associated with the indoor, outdoor (irrigation), and stock water estimates. These sources of uncertainty, potential effect on the water use estimates, and how the uncertainties were accounted for in this evaluation include:

- Indoor water use was based largely on wintertime meter data from three incorporated cities that may not be representative of exempt well parcels, due in part to generally smaller lot sizes, customers being charged for water use, and requirements for municipal suppliers to promote efficiency. This is expected to have only a minor effect on the consumptive water use estimates. Outdoor irrigation use is likely more sensitive than indoor use to lot size, pricing structure, or efficiency measures. Published estimates of indoor water use fall in a relatively narrow range, and the estimate recommended in this report is consistent with other studies.
- Indoor water use estimates based on Group A water system data may include an unknown number of part-time residences, resulting in an underestimate of indoor water use. This was partially addressed by not including water meter records for connections that did not meet a minimum monthly or seasonal water use threshold.
- Parcels selected for aerial photograph analysis of exempt well irrigation may include some parcels with non-exempt water irrigation rights. The *Instream Flow Reservation Tracking Database* (Aspect, 2011) developed for the MWC was used to randomly select only developed, single-family residences, served by exempt sources and not receiving irrigation water. The database includes water system and irrigation district service areas, allowing parcels served by those entities to be excluded; however, information on ownership and validity of private water rights are beyond the scope of the database. This uncertainty was partially addressed by excluding parcels that, on review of the aerial photographs, showed clear evidence of irrigation beyond the 0.5-acre exempt well limit, but it is still possible some parcels served by non-exempt water sources were included. This would have the effect of overestimating the area irrigated by exempt sources, and in turn overestimate the average irrigation water use.
- Distinguishing between irrigated areas and natural vegetation in aerial photographs is not always certain, especially near surface water bodies. Septic drain fields can also falsely appear to be irrigated. Inclusion of some non-irrigated areas as irrigated based on the presence of green vegetation likely results in some overestimate of average irrigated area by exempt wells in the watershed, and in turn conservatively overestimates the average irrigation water use.

- Total number of livestock in the watershed is based on information from the *Methow Basin (WRIA 48) Watershed Plan* and agricultural census data from Okanogan County. County-scale data may not accurately reflect changes in livestock populations in the watershed, resulting in uncertainty in livestock numbers and associated water use. It is expected that the average number of livestock per developed parcel will decrease over time, as new parcels served by exempt wells are developed primarily for residential rather than commercial agricultural uses. The assumption of an average of one head of livestock per residence served by an exempt well under the reservation is considered to be conservative.

The largest component of total and consumptive water use is outdoor irrigation, followed by indoor water uses, and then stock water. Of the maximum month consumptive use rate of 710 gpd per residence, a 650 gpd or 92 percent is associated with irrigation use. The remaining 60 gpd, or 8 percent, is evenly divided between indoor and stock water consumptive use. Because irrigation use is the dominant component of the estimated water use, uncertainty in the irrigation use produces the greatest amount of uncertainty in overall water use.

Two independent methods to estimate outdoor water use (subtracting indoor use from total use in Group A data and an aerial photo analysis) produced similar results, providing additional confidence in the irrigation water use estimate. Some of the uncertainty in irrigation water use was addressed by making reasonably conservative assumptions that produce a moderately high bias in the estimated use. These include using an average irrigated area per exempt well that is slightly higher than the watershed-wide average (0.10 acres used versus 0.08 measured average); the likely inclusion of parcels receiving irrigation water from non-exempt sources; and the likely inclusion of some non-irrigated areas as irrigated.

The uncertainties in indoor and stock water use are expected to have minimal impact on the estimated consumptive water use. For example, if either of these uses is actually twice the estimated value, the impact would only be about a 4 percent increase in the maximum month consumptive use.

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Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Methow Watershed Council for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

Table 1 - Other Estimates of Domestic Water Use in Washington State

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WRIA 48 Water Withdrawal Study Project No. 080180

Estimated Use (gpd)	Region	Source
598 ADD, 1,189 MDD	Methow	Watershed Plan – WRIA 48, based on Town of Twisp data from 2000
220-260 ADD	Methow	Town of Twisp data (Highlands Associates, 1993)
185 ADD (indoor)	Methow	Dept of HUD (Highlands Associates, 1993)
360 ADD	Nationwide	American Water Works Association (Highlands Associates, 1993)
403 ADD	Statewide	Washington Rural Water Association (Highlands Associates, 1993)
490-980 ADD	Spokane	Watershed Plan – WRIA 55/57
367 ADD	Waterville	Watershed Plan – WRIA 44/50
670 ADD	Mansfield	Watershed Plan – WRIA 44/50
900 ADD	Yakima	Watershed Plan – WRIA 37/38/39
380 ADD	Wenatchee	Watershed Plan – WRIA 45
950 MDD	Wenatchee	Watershed Plan – WRIA 45
700-900 ADD	Okanogan	Watershed Plan – WRIA 49
1,500 MDD	Eastern WA	WDOH Water System Design Manual (2009)
350 MDD	Statewide	WDOH WSDM statutory minimum for analogous system design
200 ADD	Statewide	WDOH WSDM minimum observed
175/350 ADD (consumptive with and w/o OSS)	Skagit River	Skagit River Management Rule – WRIA 3&4, WAC 173-503 (5/15/06)
250 growing season (consumptive, with OSS)	Quilcene–Snow	Water Management Rule – WRIA 17, WAC 173-517-160 (11/30/09)
13 (consumptive, indoor use only with OSS)	Quilcene–Snow	Water Management Rule – WRIA 17, WAC 173-517-160 (11/30/09)
240/800 (with and w/o OSS)	Grays-Elochoman	Proposed Water Management Rule – WRIA 25, WAC 173-525 (4/19/2010)
240/800 (with and w/o OSS)	Cowlitz	Proposed Water Management Rule – WRIA 26, WAC 173-526 (4/19/10)
240/800 (with and w/o OSS)	Lewis	Instream Flow Rule – WRIA 27, WAC 173-527 (12/19/08)
240/800 (with and w/o OSS)	Salmon Washougal	Instream Flow Rule – WRIA 28, WAC 173-528 (12/19/08)

GPD - gallons per day

ADD – Average day demand

MDD – Maximum day demand

WDOH – Washington Department of Health

OSS – On-site septic system

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Table 2 - Group A Community Water Systems in WRIA 48

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WRIA 48 Water Withdrawal Study Project No. 080180

System Name	Number of Connections	System Included in Evaluation?	Notes
EDELWEISS MAINTENANCE COMMISSION	181	Yes	Monthly data evaluated for 2006 through 2010. Source (well) meter data only, no connection meter data.
PATEROS WATER DEPARTMENT	373	Yes	Monthly (May through October) residential connection meter data evaluated for 2010. Single meter reading for winter period (November through April). System service area is largely outside of WRIA 48, but a portion is located in Lower Methow reach.
TOWN OF TWISP	661	Yes	Monthly (April through October) residential connection meter data evaluated for 2007 through 2010.
TOWN OF WINTHROP	620	Yes	Monthly (May through October) residential connection meter data evaluated for 2006 through 2010. Single meter reading for winter period (November through April).
ALTA LAKE GOLF COURSE PLAT	72	No	Unable to contact manager for this water system.
METHOW WATER SYSTEM INC	24	No	Unable to contact manager for this water system.
PINE FOREST WATER SYSTEM	84	No	System not included in water use study; full-time connections are only about 20 percent of all connections.
WOLF CREEK PROPERTY OWNERS ASSN	48	No	System manager contacted; system board of directors voted not to provide meter data.

Connections re the number of full-time connections approved by Department of Health.

Table 3 - Summary of Municipal Group A Water System Data

WRIA 48 Water Withdrawal Study Project No. 080180

City of Pateros

Year	Number of Residential Connections	Number of Full-Time Residential Connections	Average Daily Water Use in GPD		
			Annual	Winter (Nov - Apr)	Summer Maximum Month
2010	249	137	577	195	1,425

Town of Twisp

Year	Number of Residential Connections	Number of Full-Time Residential Connections	Average Daily Water Use in GPD		
			Annual	Winter (Nov - Mar)	Summer Maximum Month
2007	352	279	NA	NA	790
2008	358	256	267	129	795
2009	355	263	275	136	559
2010	356	254	214	137	547
<i>Average 2007 - 2010</i>	355	263	252	134	673

Town of Winthrop

Year	Number of Residential Connections	Number of Full-Time Residential Connections	Average Daily Water Use in GPD		
			Annual	Winter (Nov - Apr)	Summer Maximum Month
2006	195	114	386	162	940
2007	193	110	466	216	924
2008	189	106	428	245	999
2009	181	115	414	261	955
2010	191	103	406	264	1,016
<i>Average 2006 - 2010</i>	190	110	420	229	967

Notes:

Water use values are based on review of service connection meter data.

Full-time connections are defined as those with no more than one month in a year with an average delivery of less than 50 GPD.

GPD - Gallons per day

NA - winter 2006/2007 water use data necessary to evaluate winter and annual use were not obtained for the Town of Twisp.

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Table 3

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Table 4 - Summary of Edelweiss Group A Water System Data

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WRIA 48 Water Withdrawal Study Project No. 080180

Year	Number of Connections	Equivalent Number of Full-Time Connections ¹	Average Daily Water Use in GPD ³		
			Annual ²	Winter (Nov - Mar) ²	Summer Peak Month
2006	168	71	529	208	1,306
2007	168	71	583	240	1,186
2008	168	71	751	451	1,416
2009	168	71	611	389	1,309
2010	168	71	525	246	1,188
<i>Average 2006 - 2010</i>	<i>168</i>	<i>71</i>	<i>546</i>	<i>232</i>	<i>1,281</i>

Notes:

GPD - Gallons per day

¹Edelweiss reports 51 full-time connections and 117 part-time connections served by their main well. "Equivalent" number of full-time connections used to evaluate source meter data assumed 20 of the part-time connections are occupied at a given time, based on information in the Edelweiss system's Water Facility Inventory Form on file with Department of Health.

² System leaks detected in February and December 2008 resulted in artificially high water use in 2008 and January 2009; annual and winter use from 2008 and 2009 are not included in the *Average 2006-2010* values.

³Average water use values are equal to the average daily source meter data divided by the number of "equivalent" full-time connections.

Table 5 - Summary of Municipal Group A Water System Characteristics

WRIA 48 Water Withdrawal Study Project No. 080180

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Water System	Parcel Size in Acres		Average Annual Precipitation in Inches	Average Maximum Daily July Temperature in Degrees F
	Average	Median		
City of Pateros	0.40	0.24	11.54	88.63
Town of Twisp	0.60	0.25	14.48	85.77
Town of Winthrop	0.48	0.26	15.05	85.60

Climate data are from the Oregon State University PRISM database for the period 1971 through 2000 (<http://www.prism.oregonstate.edu/>).

Parcel sizes are for residential parcels within the respective water system service areas, determined using the Instream Flow Revision tracking database developed by Aspect Consulting for the Methow Watershed Council.

Table 6 - Irrigated Area of Parcels Served by Exempt Wells

WRIA 48 Water Withdrawal Study Project No. 080180

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Reach	Parcels Evaluated	Parcels with Irrigation	Percent of Parcels with Irrigation	Maximum Irrigated Area (Acres)	Average Irrigated Area (Acres)
Headwaters	18	2	11%	0.49	0.03
Upper Methow	30	11	37%	0.39	0.04
Chewuch	38	11	29%	0.50	0.07
Middle Methow	23	8	35%	0.50	0.09
Twisp River	17	6	35%	0.28	0.07
Lower Methow	84	31	37%	0.50	0.10
All Reaches	210	69	33%	0.50	0.08

Parcels are limited to developed parcels apparently served by exempt wells and with no other known source of irrigation water, selected randomly selected using the Instream Flow Revision tracking database developed by Aspect Consulting for the Methow Watershed Council. These represent about 10 percent of all parcels in the watershed meeting the above criteria for development and source of water. Irrigated area measured from aerial photographs was limited to a maximum of 0.5 acres allowed for exempt well uses.

Table 7 - Climatic Data by Reach and Washington Irrigation Guide Station

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WRIA 48 Water Withdrawal Study Project No. 080180

Reach or WIG Station	Average Monthly Precipitation in Inches												Annual	May - Sep Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Methow WIG Sta.	1.54	1.42	1.13	0.82	1.15	0.89	0.49	0.61	0.60	0.70	1.79	1.96	13.10	3.74
Winthrop WIG Sta.	2.00	1.50	1.05	0.77	1.02	1.06	0.80	0.72	0.61	0.93	1.99	2.60	15.05	4.21
Headwaters Reach	3.61	2.60	1.68	1.01	1.08	1.09	0.81	0.81	0.81	1.44	3.40	3.94	22.29	4.60
Upper Methow Reach	3.04	2.18	1.40	0.87	1.08	1.12	0.82	0.79	0.69	1.16	2.91	3.41	19.49	4.51
Chewuch River Reach	3.23	2.34	1.50	0.93	1.12	1.17	0.87	0.81	0.74	1.25	3.11	3.60	20.66	4.70
Middle Methow Reach	2.36	1.77	1.22	0.85	1.11	1.15	0.88	0.74	0.65	0.98	2.37	2.87	16.95	4.53
Twisp River Reach	2.50	1.90	1.31	0.88	1.09	1.16	1.08	0.73	0.70	1.06	2.69	3.18	18.27	4.76
Lower Methow Reach	1.91	1.57	1.32	0.95	1.13	1.17	0.76	0.69	0.61	0.90	2.12	2.38	15.51	4.36

Reach or WIG Station	Avg. Daily Maximum Temperature in Degrees F		
	Jul	Aug	Annual
Methow WIG Sta.	87.6	88.0	60.7
Winthrop WIG Sta.	85.6	85.9	59.2
Headwaters Reach	81.1	81.5	55.8
Upper Methow Reach	82.2	82.5	56.7
Chewuch River Reach	81.1	81.5	55.8
Middle Methow Reach	82.6	82.8	57.0
Twisp River Reach	81.8	82.0	56.5
Lower Methow Reach	82.3	82.7	57.1

Notes:

WIG - Washington Irrigation Guide

Data for the Methow and Winthrop WIG stations are from the Western Regional Climate Center for the period 1971 through 2000 (<http://www.wrcc.dri.edu>).

Reach data are spatially averaged data over developable parcels in each reach as identified in the Instream Flow Revision tracking database;

original gridded climatic data are from the Oregon State University PRISM database for the period 1971 through 2000 (<http://www.prism.oregonstate.edu>).

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Table 8 - Total and Consumptive Exempt Well Irrigation Use

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WRIA 48 Water Withdrawal Study Project No. 080180

Month	CIR in Inches	TIR in Inches	TIR in ac-ft	CU in inches	CU in ac-ft	Total Use in GPD	Consumptive Use in GPD
June	3.47	4.63	0.04	3.93	0.03	465	395
July	6.52	8.69	0.07	7.39	0.06	761	647
August	4.85	6.47	0.05	5.50	0.05	566	481
September	3.69	4.92	0.04	4.18	0.03	445	379
October	0.08	0.11	0.00	0.09	0.001	41	35
Annual	18.61	24.81	0.21	21.09	0.18	185	157

Acres: 0.10
 Crop: Pasture/Turf
 WIG Station: Winthrop
 Irrigation Season: June 3 to October 7
 Application Efficiency: 75%
 Evaporation: 10%

Notes:

CIR - Crop Irrigation Requirement
 TIR - Total Irrigation Requirement, equals CIR/Application Efficiency
 CU - Consumptive use, equals TIR*(Application Efficiency + Evaporation)
 WIG - Washington Irrigation Guide
 ac-ft - acre-feet
 GPD - gallons per day

Table 9 - Livestock Census for Okanogan County

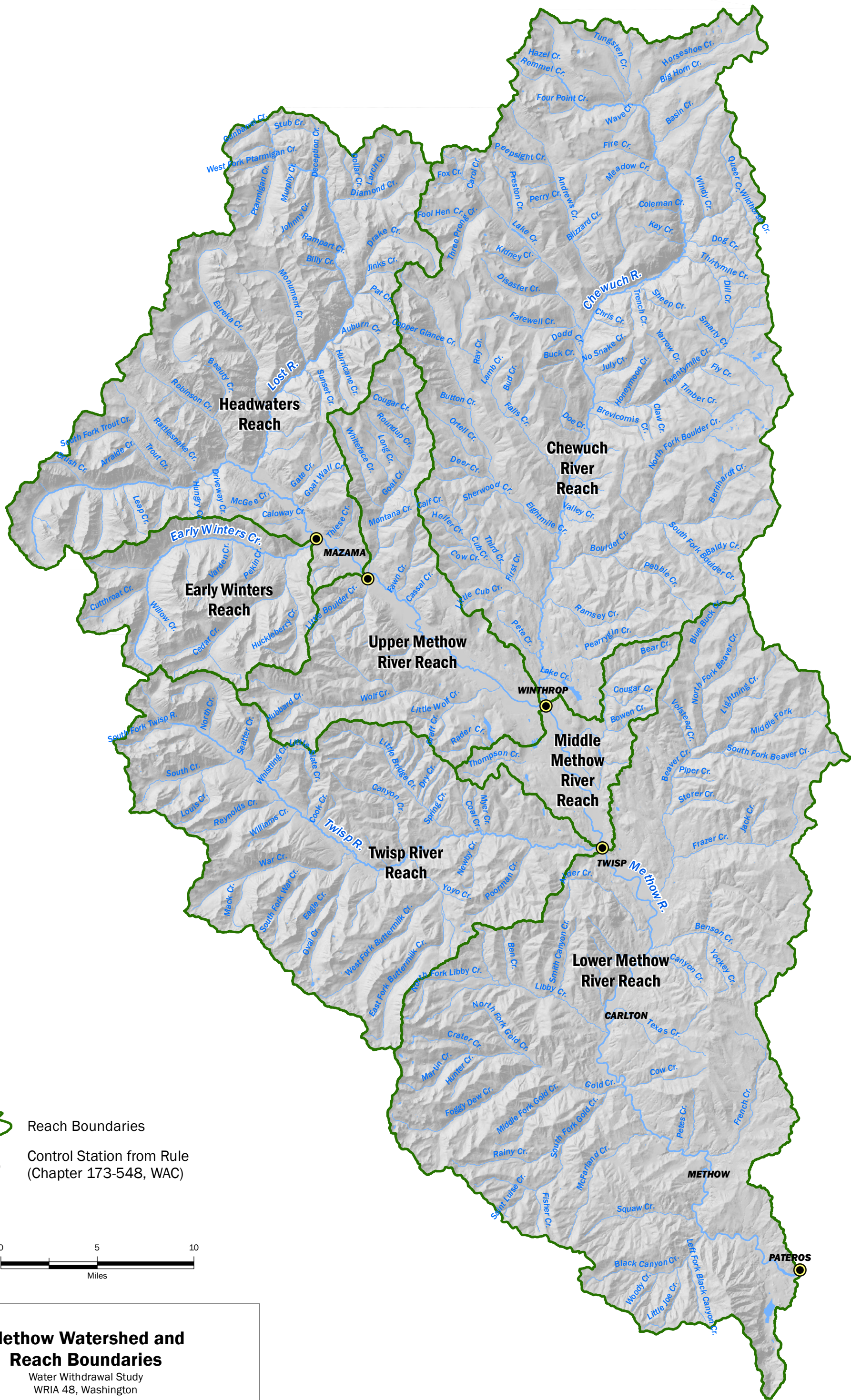
WRIA 48 Water Withdrawal Study Project No. 080180



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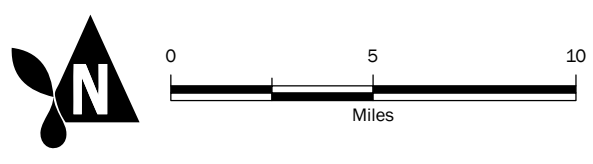
	Year and Number of Livestock			Average Water Use in GPD per Head
	1997	2002	2007	
Cattle, including calves	52,207	43,602	44,551	12 to 20
Hogs	380	293	256	4 to 6
Poultry	1,925	3,311	3,842	0.05 to 0.25
Ponies and Horses	4,595	5,084	6,229	12

Sources: USDA Agricultural Censuses for 1997, 2002, and 2007.

Washington Department of Health Water System Design Manual (2009)



-  Reach Boundaries
-  Control Station from Rule (Chapter 173-548, WAC)



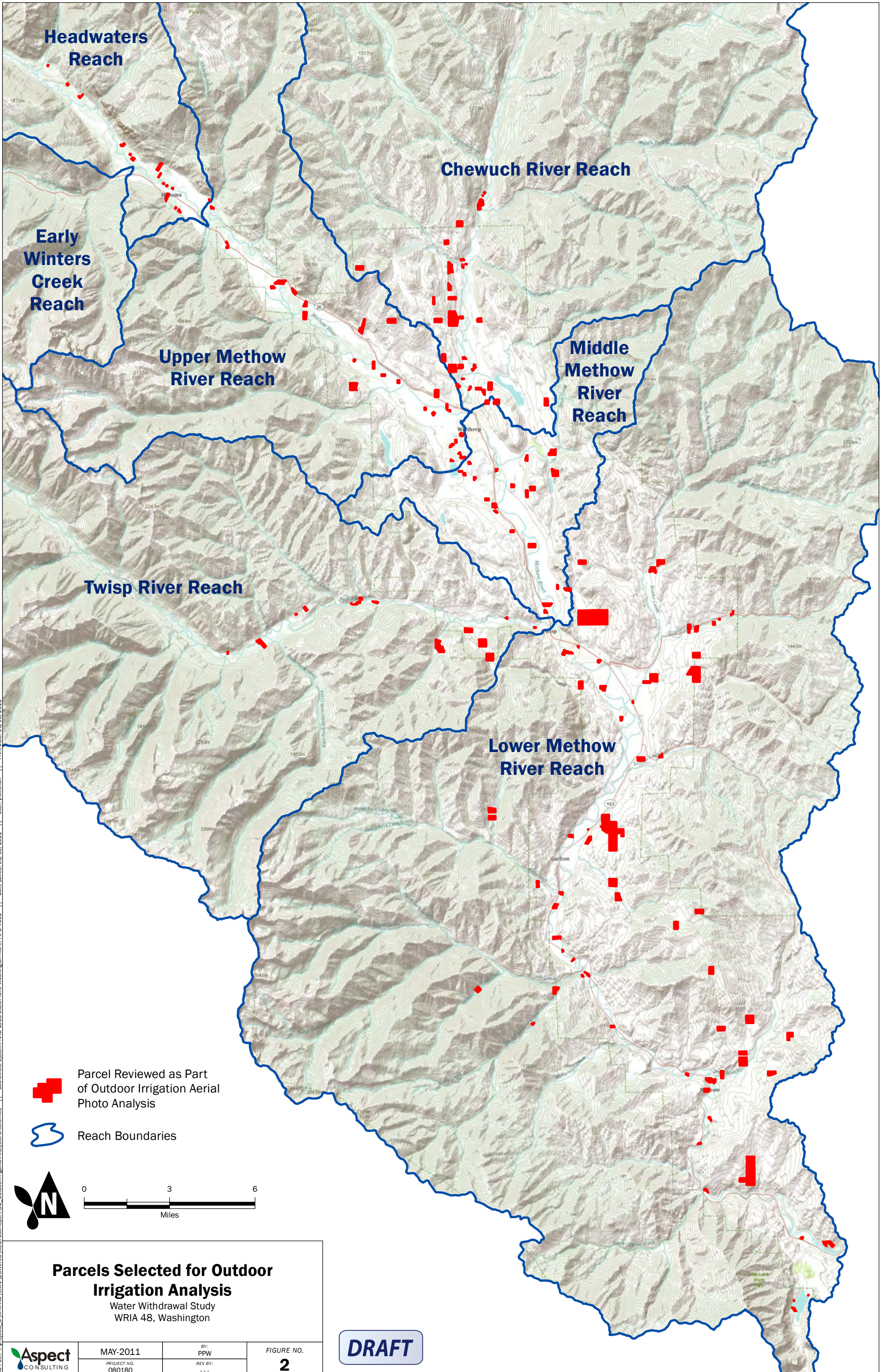
Methow Watershed and Reach Boundaries
 Water Withdrawal Study
 WRIA 48, Washington





MAY-2011	BY: PPW	FIGURE NO. 1
PROJECT NO. 080180	REV BY: ---	

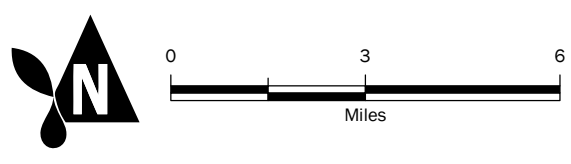
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GIS Path: T:\projects_8\WRIA48\MWG\Delivered\WaterUseReport\02_OutdoorIrrigationAnalysis\Parcels.mxd | Coordinate System: NAD_1983_StatePlane_Washington_North_FPS_4603 | Date Saved: 05/09/2011 | User: paitman | Print Date: 05/09/2011

-  Parcel Reviewed as Part of Outdoor Irrigation Aerial Photo Analysis
-  Reach Boundaries



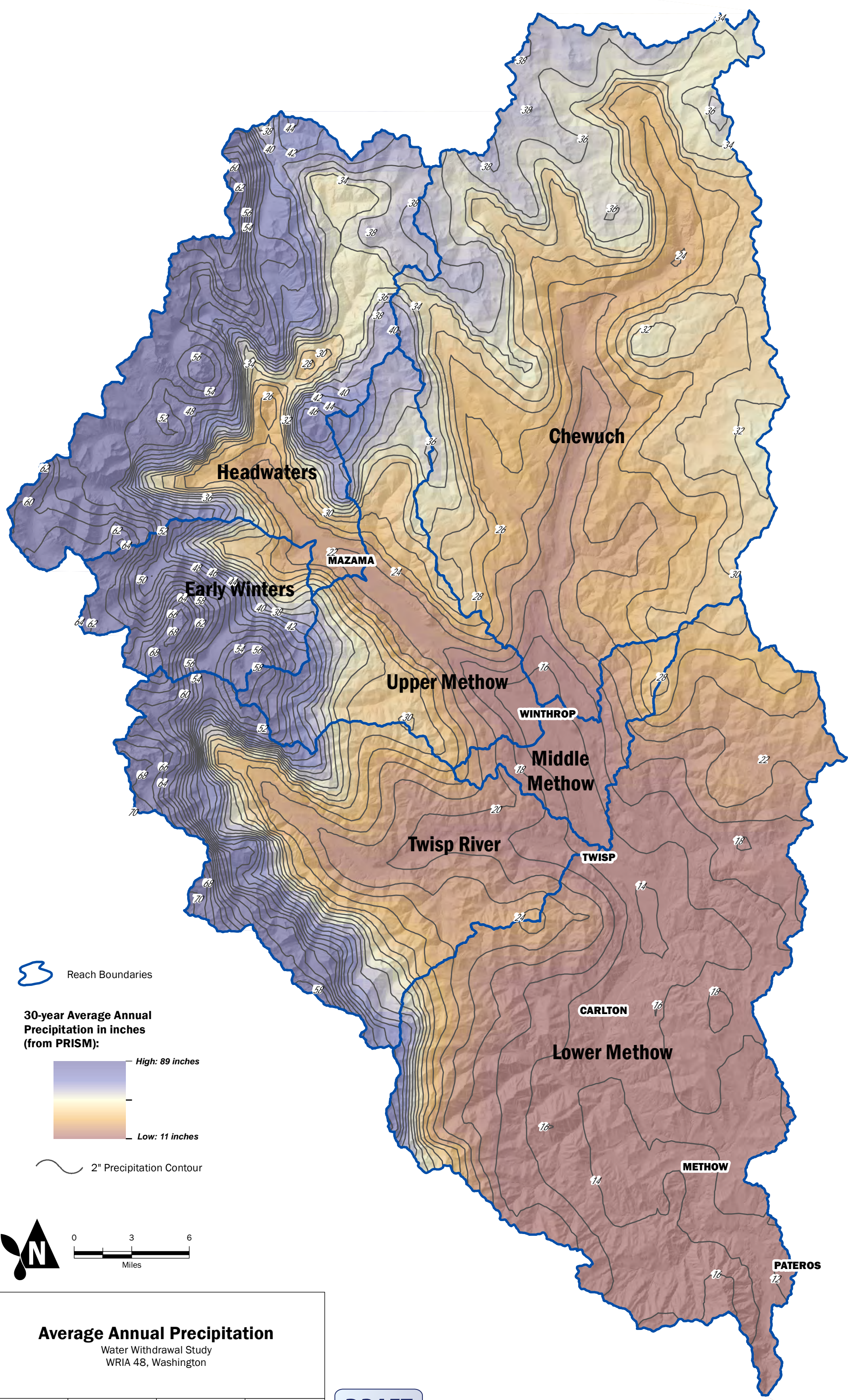
Parcels Selected for Outdoor Irrigation Analysis
 Water Withdrawal Study
 WRIA 48, Washington



MAY-2011	BY: PPW	FIGURE NO. 2
PROJECT NO. 080180	REV BY: ---	

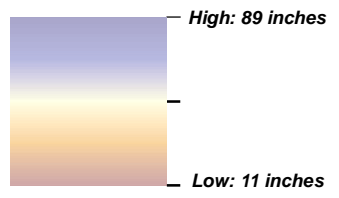
DRAFT

GIS Path: T:\projects_8\WRIA48\MWG\Delivered\WaterUseReport\03_AvgAnnualPrecip.mxd | Coordinate System: NAD_1983_StatePlane_Washington_North_FIPS_4601 | Date Saved: 05/09/2011 | User: pwlittman | Print Date: 05/09/2011

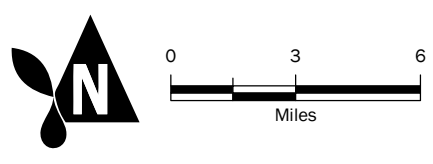


Reach Boundaries

30-year Average Annual Precipitation in inches (from PRISM):



2" Precipitation Contour



Average Annual Precipitation
 Water Withdrawal Study
 WRIA 48, Washington



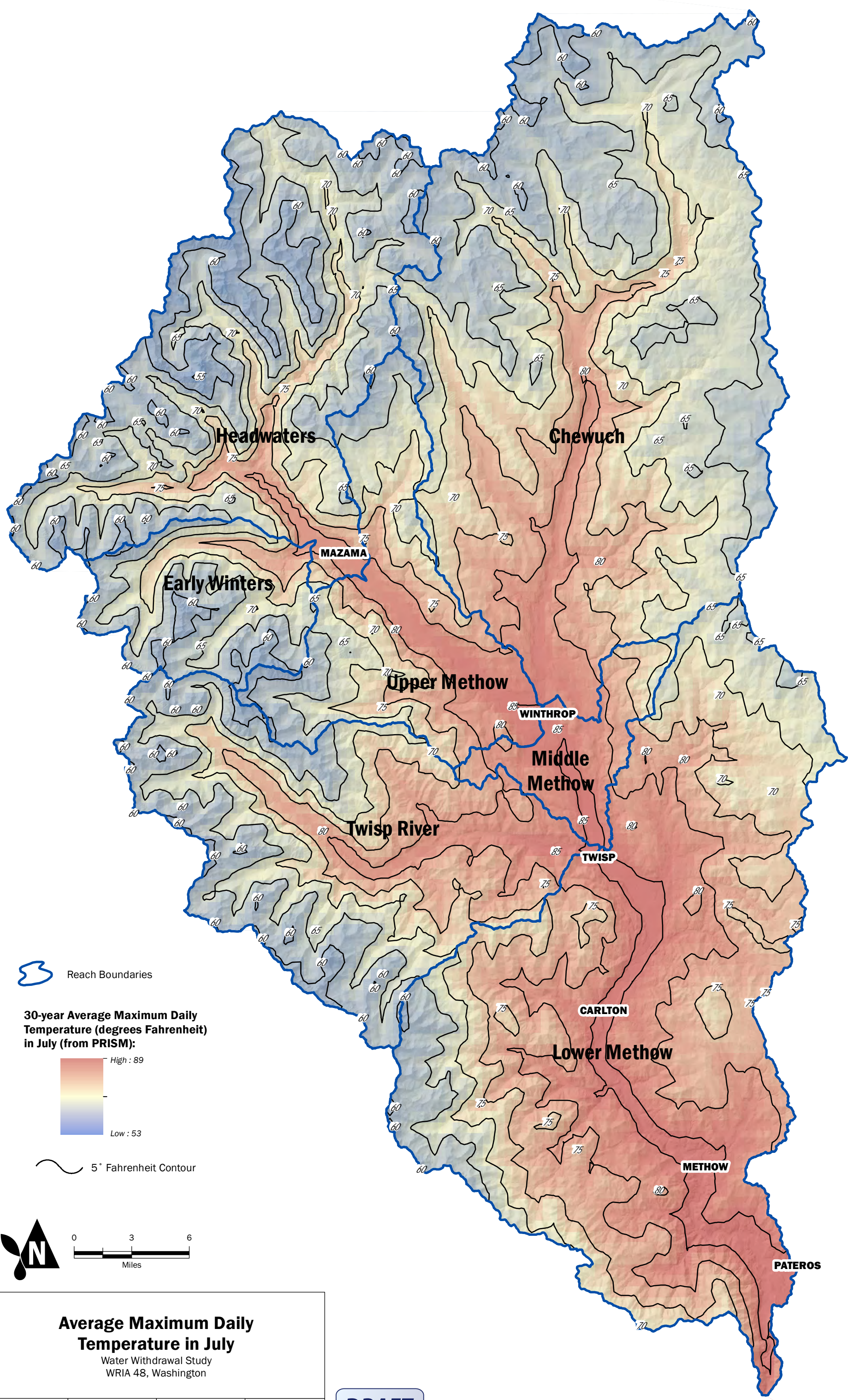
MAY-2011
 PROJECT NO.
 080180


BY:
 PPW
 REV BY:

FIGURE NO.
3

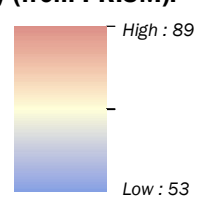
DRAFT


GIS Path: T:\projects_8\WRIA48_MWCO_Delivered\WaterUseReport\04_AvgMaxJulyTemp.mxd | Coordinate System: NAD_1983_StatePlane_Washington_North_FIPS_4601 | Date Saved: 05/09/2011 | User: pwlittman | Print Date: 05/09/2011



 Reach Boundaries

30-year Average Maximum Daily Temperature (degrees Fahrenheit) in July (from PRISM):



 5° Fahrenheit Contour



Average Maximum Daily Temperature in July
Water Withdrawal Study
WRIA 48, Washington



MAY-2011
PROJECT NO.
080180

BY:
PPW
REV BY:

FIGURE NO.
4

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APPENDIX A

Aerial Photograph Analysis of Irrigation by Permit-Exempt Wells

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