10. WATER USE

Water use estimates for historic, current, and future conditions is a required element of watershed planning under RCW 90.82. Types of water use in the Methow are characterized in this report according to the following categories:

- Agricultural;
- Municipal (including commercial and residential);
- Rural residential – Exempt wells; and
- Non-irrigated lands.

10.1 Background Issues

Overall water use in the basin can be broken down into two components; consumptive and non-consumptive use. The non-consumptive use component is characterized by water that, after being put to beneficial use, is returned to the hydrologic system via mechanisms such as wastewater treatment plants, septic systems, and infiltration of excess irrigation water. Consumptive water use is water that is not returned to the Methow basin hydrologic system after use. Examples of consumptive water use include evapotranspiration from forestland and agricultural crops, evaporation of open water, and water used for landscaping and home gardening.

Much of the discussion of basin-wide water use in this Chapter considers only consumptive use, as water from non-consumptive uses (water that is not permanently removed from the system) is returned to streams or groundwater after being put to beneficial use, and does not impact the overall basin-wide water balance.

Background water use issues are a combination of regulatory and technical issues. Issues related to water use include:

- Irrigation, either as agricultural or urban landscaping applications, usually represents the largest human use of water. Much of this irrigation water is lost to the atmosphere or transpired by vegetation and is difficult to measure.
- Irrigation systems in the Methow generally convey water to the final user by means of irrigation ditches. Most of the ditches are unlined and have a tendency to lose water though seepage. The water associated with irrigation seepage and eventual discharge to streams is important to watershed planning.
- The Methow has experienced increased rural, seasonal, and recreational development. These developments are not typically dependent on municipal water supplies and use exempt wells as a water supply. To better understand the effects of “Exempt Wells” on groundwater resources an estimation of their number, their spatial distribution, and the amount of water consumptively used by exempt well users needs to be understood.
- Forested lands (as compared to urban and agricultural land) encompass the greatest percentage of land cover in the basin. Evapotranspiration losses through

forest vegetation comprise a large and significant component of the overall consumptive water use in the basin. Current and historic forest management practices could potentially affect evapotranspiration rates, and subsequently, overall water use in the basin.

- Ideally, the legal allocation of water should correspond to actual use of water. Historically, water for agricultural purposes has been legally allocated using generalized relationships between irrigated area and water allocation needs. The relationship between historical allocation formulas and actual water use is important for planning a water strategy.

10.2 Objective and Level of Detail

Water use estimates for historic, current and future conditions are a required element of watershed planning under RCW 90.82. Historical water use data are aggregated for the Methow Basin as a whole. Current water use in the basin is aggregated according to the 8 sub-basins described in previous sections. Estimates of future water use are aggregated by sub-basin where possible, and for the basin as a whole based on land use assumptions made by the Methow Basin Planning Unit (MBPU).

The majority of primary water uses in the basin can be quantified using existing data. The estimates of actual water use rely on characterizing a number of water use components, and discussing how they relate to overall water use in the basin. Water use is characterized and discussed for the following components:

- Irrigation Diversions,
- Irrigation transportation losses,
- Sub-basin transfer via irrigation canals around regulatory baseflow compliance points,
- Agricultural on-farm efficiency,
- Crop Irrigation Requirement,
- Municipal withdrawals,
- Other permitted wells (e.g. Class A and B water systems),
- Exempt well withdrawal,
- Return flow (irrigation, domestic, municipal), and
- Consumptive use from non-irrigated lands.

10.3 Technical Background

Watershed planning typically focuses on the water balance and the way that humans affect it through water use. Water use can be broken into two components, consumptive use and water returned to the hydrologic system.

The issues affecting water use as they relate to watershed planning in the Methow include:

- The land use and land cover patterns that govern the spatial and temporal distribution of water use. This is discussed in Section 9.
- The relative amount of consumptive water use. Different activities use water at different rates. For example, per acre consumptive use from alfalfa is lower than for orchards. Net consumptive use for municipal purposes can be less than for exempt wells because of price incentives or lot size restrictions.
- The parameters that affect efficiencies in current water use practices. For the Methow, a clear distinction has been made between on-farm efficiencies and canal transportation losses.

10.3.1 Agricultural Consumptive Use

The components affecting water use resulting from irrigated agriculture are discussed below.

Crop Irrigation Requirement

Crop Irrigation Requirement (CIR) is water "lost" to the atmosphere from evaporation and transpiration, "evapotranspiration" (ET), through a plant minus precipitation. It is also referred to as irrigation consumptive use. CIR is typically reported in inches. Multiplying irrigated acreage by consumptive use or CIR results in a total volume of water consumed by the irrigated crop.

In order for the full theoretical amount of CIR to be consumed by a plant, irrigation water must be applied at optimal timing intervals and rates to maintain optimal soil moisture conditions for plant growth. Applying less water will result in less water being evapotranspired, while greater watering will result in return flow. Therefore, CIR represents a theoretical maximum consumptive loss as a result of crop evapotranspiration. CIR is calculated using the following equation:

$$CIR = ET_{crop} - \text{precipitation}$$

ET is a measurement of the total amount of water needed to grow plants and crops. Since different plants have different water requirements, they will have different ET rates. Crop evapotranspiration (ET_{crop}) can be estimated by direct measurement or by calculated from empirical equations. A rigorous estimate of ET can be calculated using localized meteorological data (temperature, precipitation, wind run, solar radiation, dew point).

CIR is usually expressed as a total value (in inches) over the growing season. However, during crop growth the CIR is not used at a consistent rate. It is dependent on the crop growth cycle and varies over the growing season. Monthly CIR is often used to better represent crop needs during the growing season. The total CIR is equal to the sum of the monthly CIR.

CIR is expressed by WSU using return periods. A return period describes the level of irrigation that would be adequate based on historical climate data. For example, a return period of 5 years corresponds to the CIR necessary for irrigation to be adequate for crops for 4 out of 5 years.

On-Farm Irrigation Efficiencies

Consumptive water use from agricultural irrigation cannot only be attributed to the Crop Irrigation Requirement of a crop. An additional consumptive use component of irrigation is water lost as a result of on-farm system inefficiencies. The total quantity of on-farm irrigation water use accounts for irrigation system “efficiency” losses from evaporation, spillage, sprinkler set-times, wind drift from sprinkler irrigation, surface runoff and excessive subsurface drainage.

The on-farm efficiency of an irrigation system is the combination of two efficiencies:

- **Application efficiency** is most often associated with sprinkler irrigation. However it is applicable to multiple methods of irrigation. It can be viewed as a measurement of the water losses from the time water leaves the nozzle, until it infiltrates into the soil. The principle component is "spray drift" lost due to evaporation of the water droplets in the air. Application losses also include evaporation from ponding water or the wet soil surface, and runoff, which results from applying water faster than the infiltration rate of the soil. Runoff is common with surface irrigation unless agronomic or water management practices are used (Fipps, 1995).
- **Distribution efficiency** is a measurement of how uniform the water is applied over the area or field. With poor uniformity, some areas receive too much water and others too little. To compensate for poor distribution efficiency, an irrigator may apply excessive amounts of water to ensure that all areas receive enough. Uniformity is not only a potential problem in sprinkler and surface systems. Drip irrigation systems, if not designed properly, can also have very poor distribution efficiencies as well (Fipps, 1995).

Irrigation Transportation Losses

The magnitude and seasonal pattern of conveyance losses are dependent on the saturated and unsaturated soil properties beneath the canal, the presence or absence of liner material which would reduce the permeability of the canal bottom (this would include natural materials such as organic debris or silt), the elevation of the water surface in the canal, and the elevation of the underlying groundwater table, and the elevation of adjacent discharge boundaries such as streams or wetlands. There are many different settings and combinations of these parameters. As discussed in Section 6, recharge and resulting changes to groundwater elevations can be significant from canal leakage, but is dependent on the scale of irrigation leakage relative to groundwater flow volumes and associated water levels.

Irrigation systems in the Methow generally convey water to the users by means of irrigation ditches. The ditches are unlined and have a tendency to lose water through seepage to the underlying aquifer.

Return Flow

The efficiency of canal and on-farm practices determines how much water not used by crops returns to the hydrologic system.

Poor on-farm efficiency occurs when the rate of water applied exceeds the infiltration rate of the soil. As a result the excess water will be lost to offsite runoff. Some of this water will return to rivers and streams. However, the surface runoff can collect in surface reservoirs such as depressions, drainages and near surface soil pores. These areas are prone to evaporation. The amount of water lost to evaporation from these areas is difficult to quantify, since it is highly dependent on individual irrigator's habits (set times, irrigation timing, etc.).

The deep percolation of water usually results in groundwater recharge. This recharge water will eventually return to rivers and streams. However, a lag time between the application period and the return to the fluvial system will be evident. The lag time could range from days to years and is highly dependent on subsurface conditions. This is discussed in Section 6 (Groundwater).

Return flow also occurs directly when canal diversion exceeds the needs of users. In this case, diversions are returned directly to the stream via canal dumps.

10.3.2 Domestic Water Use

Three distinct water use populations were identified within the basin.

- Permanent-resident, municipally supplied users.
- Permanent-resident, exempt well users
- Seasonal resident, exempt well users

Municipal Water Use

In general, municipal water use is comprised of two components: base use and peak use. Municipal water use is typically expressed on a per capita (per person) basis and a peaking factor is commonly used to represent the increase in outdoor watering during the summer.

Base Use

Year-round base use is generally interior use that is returned to the hydrologic system via a wastewater treatment plant or septic system. Base water use has a non-consumptive and a small consumptive use component. The non-consumptive component is driven by daily year round uses: including cooking, personal hygiene, laundry and other indoor water uses. The consumptive component is attributable to system leakage and interior evaporation. Base water use is usually fairly consistent throughout the year. Generally, water use during the non-growing season, October through March, can be a good indicator of base water use.

Peak Use

During the months of April through September water use increases substantially. The increased water use is commonly discussed in terms of a peaking factor. Peaking factors typically range between 2 and 4 times the base, indoor per capita usage. These peak summer water uses above base water use are assumed to be driven by outdoor use; including lawn and garden watering, car washing and other outdoor uses. This peak or outdoor water use is a consumptive use of water since it may be lost to evaporation, soil wetting, evapotranspiration, etc. Typically, a large percentage of total annual residential water use is peak summer (outdoor) use. In the Methow, summer use is also affected by increased tourist use.

Wastewater Return

Municipal wastewater is discharged via wastewater treatment facilities. If the water is returned to the surface water basins that produced the water originally, this discharge is a return flow to the system. Wastewater discharge records are useful for determining actual consumptive use of water. The difference between wastewater discharge and withdrawal equals municipal consumptive use.

<u>Exempt Well Use</u>

Exempt wells are a concern in watershed planning because the total number of wells and quantity of water withdrawn is not known. Although exempt wells are permitted to use up to 5,000 gallons a day for multiple purposes (maximum annual use of 5.6 AF/yr), they are usually used to provide a much smaller volume to domestic homes.

Items affecting water use from exempt wells include:

- Population;
- Base water use;
- Peak water use;
- Net consumptive use; and
- Return flows.

The methods used to estimate the number of exempt wells and their quantity of water used typically assume that the population outside of the service areas of purveyors is served by exempt wells. Exempt well water use patterns typically mirror that of the municipal system. However, higher or lower use patterns are possible from exempt wells.

Variables contributing to higher water use from exempt wells include:

- There is no meter charge for exempt wells as there is for water supplied by municipal purveyors, therefore there is less incentive to conserve water (other than the electrical bill associated with pump operation);
- Exempt wells occur in rural areas with larger lot sizes. Therefore landscaping and garden use can be higher than in more developed areas; and
- Exempt wells occur in rural areas that commonly support livestock with wells.

Variables contributing to lower water use from exempt wells include:

- Exempt wells may be installed in less productive aquifers which limit the volumes of water that can be withdrawn.
- Exempt wells may support homes in rural areas that do not have any landscape water needs.
- Exempt wells commonly support seasonal vacation homes that are not regularly occupied. County assessor data (see Section 9) suggests that 38% of residential properties are vacation homes.
- Exempt wells are also located on vacant lots with no actual water use.
- Properties with irrigation rights would only use their exempt wells for indoor use, resulting in lower consumptive use of the exempt well.

10.3.3 Consumptive Use from Forested Lands

Since the Methow is a highly forested watershed, water use from forest land is an integral part of the basin's water budget. Approximately 86 percent of the land in the Methow is forested (Okanogan and Colville National Forests Vegetation Mapping Project, 1999).

Determining forest water use and the potential effects on water availability is a complicated problem. It is a controversial issue among land managers and various interest groups (Keppeler, 1998). Stream flows from forested ecosystems are directly dependent upon multiple factors. The relative magnitudes, timings, and significance of these factors are dependent on the natural forest regime and forest management practices. Table 10-1 lists several generalized changes, which may occur and affect hydrologic water balance components resulting from forest coverage alteration.

Watershed studies have been conducted in other areas to estimate the effect of logging on the water yield of a basin. However, conclusive generalized statements regarding these effects cannot be justified. Some studies have found that annual stream flow yields have been altered by stand density reduction (Fritschen, L., 1997), while others have found that this is not always the case (Rhodes, J., 1998).

The basal area of a single tree is the surface area of a tree as if it were cut at a height of 4 or 5 feet above ground. The total surface area of all trees represents the basal area of a forest stand, expressed in units of square feet per acre. Basal areas are commonly used in forest management since they describe the density of harvestable timber. Basal areas also affect water use: forest stands with higher basal areas use more water. Figure 10-1 shows the relationship between basal area and transpiration rate for several tree species at the Rocky Mountain Experiment Station in Colorado.

To determine the transpiration rate for a given tree species requires the use of Leaf Area Index (LAI). The LAI describes a fundamental property of the plant canopy in its interaction with the atmosphere and represents all the upper surface of the plant's leaves projected downwards to a unit area of ground under the canopy. To determine the LAI for forested acreage, a relationship been LAI and a tree's basal area can be used. Knowing the basal area, the transpiration for several tree types can be calculated using the empirical relationships between basal area and transpiration shown in Figure 10-1.

As with agricultural crops where water use is dependent on an individual crop type, water use between tree species also differs. Some tree species use water conservatively while others are liberal water users. For example, Lodgepole Pine with a basal area of 15 m^2/hactare transpires 105 mm/yr, while sub-alpine fir with basal area of 15 m^2/hactare transpires 125 mm/yr, and Engelmann Spruce with basal area of 15 m^2/hactare transpires 180 mm/yr (Alexander, R.R., et al, 1985). Therefore, if there is a significant difference in species type between a "natural" and "managed" watershed, differences in streamflow could be attributed, in part, to the altered species distribution.

10.4 Existing Data

This section summarizes existing data and/or studies relevant to determining water use.

10.4.1 Irrigation Diversions

Historical Diversions

The US Geological Survey (1956) reported irrigation diversion rates dating from the early 1900's to 1960 based on a survey of county land-use records and estimates of crop irrigation requirements. This study represents the best available estimate of total irrigation withdrawals prior to 1990. Table 10-2 summarizes the estimates from this study. Surveys of canal flows were conducted on several canals in the 1930s and 1940s by the State of Washington. The USGS measured flows in a number of canals in the early 1970s.

Historically, diversion amounts are estimated to range from 50,000 to 70,000 AF (140 – 200 cfs) per year. This estimate is based on the 1926 Appleby irrigated acreage coverage which considered 11,700 irrigated acres. It was assumed that the acreage was flood irrigated with an application efficiency of 40 and 50 percent and planted in pasture, a water intensive crop.

Current Diversions

The Methow Basin currently supports approximately 27 irrigation systems, which divert water from the mainstem Methow, and its tributaries. Irrigation diversions represent the quantity of water diverted directly from rivers and streams. The magnitude of irrigation diversions has been periodically evaluated over the years, and, while the total quantity of diversion has never been fully compiled in one study, a good estimate of total diversions can be reasonably well established.

Published estimates of current diversion rates can be found in the following documents:

- Williams and Kendra (1990) – Ecology estimate using water rights
- Larson and Peterson (1991) – Ecology measurements of 18 largest diversions
- Montgomery Water Group (1996): Measurements of MVID system
- National Marine Fisheries Service (1999): Diversion estimates based on screen capacities for Chewuch, Fulton, Skyline, Early Winters, and Wolf Creek Canals.
- Golder Associates (2000) – Miscellaneous measurements and personal communications with local irrigators
- USGS (2001) – Measurements of flows on Chewuch and Fulton Canal

A summary of Methow irrigation ditches and estimated diversion rates is shown on Table 10-3. Total diversion is in the range of 200 to 250 cfs. There are other small permitted surface water diversions in the basin that are not included in Table 10-3 (typically less than 2 cfs). Data for these diversions basin-wide are not available.

Recent installation of weirs and flumes on a number of irrigation diversions by the US Bureau of Reclamation (Golder Associates, 2001), in conjunction with Okanogan County, provides the ability for further refinement of diversion estimates. However, the current summary is considered to be reliable and sufficiently accurate for watershed planning purposes.

In addition to surface water diversions, water used for agricultural irrigation purposes is also obtained from groundwater sources. According to Ecology's WRATs database, water rights exist for the pumping of 12,677 AF of water. This includes water allocated between water right claims, permits and certificates. The volumes of water actually pumped by these wells have not been quantified.

10.4.2 Irrigation Transportation Losses

Irrigation systems in the Methow generally convey water to the final user by means of irrigation canals or ditches. Figure 10-2 shows the extent of irrigation canals in the

Methow Basin. This figure was developed using existing GIS coverages from the US Forest Service, combined with recent GPS mapping of selected irrigation diversions by the USBR (Golder, 2000). The total estimated length of irrigation canals in the Methow is 88 miles.

The ditches are typically unlined and have a tendency to lose water though seepage. Measurements of canal transportation losses are limited. Canal losses were measured on the Chewuch and Fulton canals by the USGS in 2001 (Table 10-4). These measurements indicate an average rate of seepage losses of up to 2 cfs per mile of unlined canal.

10.4.3 Sub-Basin transfer

The largest irrigation systems in the Methow transport irrigation water from points of diversion in tributary sub-basins to irrigated lands in the sub-basins of the Methow Mainstem. The Chewuch Canal and Fulton Canal transport irrigation water from the Chewuch sub-basin to the Middle Methow sub-basin. The MVID West canal transports irrigation water from the Twisp sub-basin to the Lower Methow sub-basin. The MVID East Canal transports water from the Middle Methow sub-basin to the Lower Methow sub-basin. The Early Winters Ditch transports irrigation water from the Early Winters sub-basin to the Methow Headwaters.

This sub-basin transfer complicates the analysis of streamflows at the stream gage compliance points for the Chewuch and Twisp Rivers. Table 10-5 shows estimated sub-basin transfer amounts for the diversions described above.

10.4.4 Crop Irrigation Requirement

Published estimates of annual crop irrigation requirements for the Methow vary from 19 to 30 inches, and can be found in the following documents:

- WSU Agricultural Research Center (1985). The most representative study location in the WSU publication is Winthrop.
- Montgomery Water Group (1996). This study focused on the Lower Methow area, specifically the MVID system.
- Golder Associates, Inc. (1998). This study was focused on the Mazama area and estimated CIR for alfalfa, pasture, and turf grass using a crop irrigation model (CRPSM).

Table 10-6 summarizes total annual CIR based on the WSU CIR tables. These estimates bracket both the Golder and Montgomery values, and are considered reliable and accurate for watershed planning purposes.

Table 10-7 summarizes the estimated monthly distribution of CIR based on crop type. This represents the percent of total CIR used in a given month. It incorporates both crop needs and seasonal temperature conditions.

Crop consumptive use can be determined by multiplying the crop irrigation requirement by irrigated area, adjusted by an on-farm efficiency factor. Table 10-8 shows the irrigated acreage by crop type, based on the MAPA coverage (Ecology, 2002). Efficiency is discussed in the following section.

10.4.5 On-Farm Efficiency

Estimates of the expected ranges in overall efficiencies of various irrigation technologies and methods are presented in Table 10-9. These irrigation system efficiencies can be significantly improved as a result of proper use and management.

Even if an irrigation system is highly efficient in terms of performance, it does not necessarily mean that it will be managed effectively. The irrigator is a key element in managing an irrigation system efficiently and achieving water savings.

The irrigator's skill in determining and applying just the amount of water needed is critical to minimizing on-farm application losses in the system (runoff, deep percolation, spray drift, etc.), and distribution losses. Unfortunately, quantifying this aspect of efficiency is difficult. In the Methow basin, agriculture is an important component of the economic and social fabric of the valley. However, intensively managed agricultural operations are not common, and the ability of individual landowners to implement "commercial-quality" irrigation practices is limited.

10.4.6 Municipal Withdrawals

The municipal systems of Winthrop and Twisp obtain water from the Methow River and several wells adjacent to the Methow River and discharge treated wastewater back to the river. Data on water diversion/pumping and discharge have been obtained from both the Towns of Twisp and Winthrop.

Historic pumping and discharge data for the Town of Winthrop are tabulated in Table 10-10. At the time this report was compiled no data on the distribution between commercial, industrial and residential water use in Winthrop was available. Therefore per capita water residential water use factors could not be calculated based on the Winthrop data. In this report per capita water use for the Town of Twisp is assumed to be representative of Winthrop's residents water use habits.

10.4.7 Municipal Water Use

Per capita water use for the Town of Twisp was estimated from monthly withdrawal and discharge records for the year 2000. The Town of Twisp serves both residential and industrial customers. The distribution between industrial and residential water use was estimated to be 24 and 76 percent, respectively (Janie Surface, 2002). The water used for residential purposes was divided by the resident population of Twisp to determine a daily per capita water use. Figure 10-3 shows the per capita water use for the Town of Twisp based on withdrawal records for the year 2000. Figure 10-4 shows the total wastewater return from Twisp based on wastewater discharge records. Daily per capita water use estimates include all non-industrial town uses (restaurants, business, pools, etc.) and potential transmission system leakage. Industrial water use is not included in these figures and was not assessed for this report.

Base Use

Base water use has both a non-consumptive and small consumptive component. Generally, water use during the non-growing season, October through March, can be a good indicator of base water use. Water diverted, by Twisp, for residential purposes between October and March is indicative of base water use. Figure 10-3 indicates that base water use averages approximately 130 gallons per day per capita (gpdpc) and the consumptive portion of that base use is between 15% and 30%.

Peak Use

Figure 10-5 shows the difference between Twisp's residential withdrawals and residential wastewater discharge (from Figures 10-3 and 10-4). This consumptive use shows peak use to be at its highest during the summer months. Maximum summer water use is on the order of 470 gpdpc, which is equivalent to a peaking factor of 3.6. Of this total summer water use, consumptive use is approximately 360 gpdpc. Approximately 76% of total annual residential consumptive water use is peak summer (outdoor) use.

Estimates of per capita peak water use for Winthrop and Twisp made in 1993 by Highland Associates ranged from between 590 and 700 gpdpc for outdoor use.

Public Water Systems

A public water system is defined as any system providing water for human consumption through pipes or other constructed conveyances, excluding a system serving only one single-family residence and a system with four or fewer connections all of which serve residences on the same farm. PWSs include but are not limited to municipalities, industrial facilities, sub-divisions, campgrounds etc. Public water systems are categorized as either "Group A" or "Group B." Group A systems are the largest and generally serve 15 or more connections. Group B systems are smaller and Group B systems and generally serve two to 14 connections. Water use by PWSs was not calculated explicitly in this report but the consumptive and non-consumptive water use by the systems was incorporated as part of the municipal and residential exempt well water use. Table 10-11 presents PWSs by sub-basin.

10.4.8 Municipal Wastewater Return

The Town of Twisp is seeking funding to resolve its current municipal water rights shortage by upgrading its existing Wastewater Treatment Facility (WWTF) to a Water Reclamation Facility (WRF). The Town is currently undertaking a study to assess the feasibility of providing a potable water service by putting reclaimed water to beneficial use. The Town has been seeking water right solutions since the loss of much of its water right in a 1997 Washington State Supreme Court Decision. To date, the Town has been unsuccessful in obtaining replacement water rights through purchase or long-term lease. The Town has decided to move forward with this water reuse alternative, which would involve construction of improvements to its WWTF.

If the WWTF is upgraded, the annual volumes pumped to the river (90 acre feet per year) would be treated to a greater degree via the WRF and returned to the river. The Town hopes that they would be able to pump an additional 90 acre-feet per year from groundwater in return. However, there is no current law or rule in place that would allow Twisp to put reclaimed water to beneficial use. The Town is currently working with Ecology on this issue.

10.4.9 Exempt Wells

Single domestic water supplies in the Methow Basin, if not provided by a municipal or purveyor system, are drawn from exempt wells. Domestic exempt well withdrawals are defined as "any withdrawal of public ground waters for stock-watering purposes, or for the watering of a lawn or of a noncommercial garden not exceeding one-half acre in area, or for single or group domestic uses in an amount not exceeding five thousand gallons a day, or for an industrial purpose in an amount not exceeding five thousand gallons a day" (Ch. 90.4050 RCW). Furthermore, after 1976, Chapter 173-548 WAC, Water Resources Program in the Methow River Basin, WRIA 48, limited exempt wells installed in the basin to single domestic and stock use.

<u>Number of Exempt Wells</u>

A detailed study involving the location and mapping of exempt wells in the Methow Basin has not been conducted. A study by Ecology in 1991 estimated the number of exempt wells for each sub-basin in the Methow valley based on land parcel information.

The number of exempt wells can also be estimated using recent population data. Population served by exempt wells was estimated using 2000 U.S. Census data. The total 2000 population of full time residents was 5600. It is assumed that the population of Twisp (955) and Winthrop (350) is serviced by the towns' systems. The towns' footprints were distributed between 3 sub-basins. The remaining resident population of 4,295 is serviced by exempt wells. Okanogan County has an average household size of 2.54 people (US Census Bureau, 2000). Therefore 1,691 permanent residences are estimated to be serviced by exempt wells. Table 10-12 summarizes the estimated number of permanent resident exempt well users in each sub-basin.

It should be noted that this estimate does not include exempt well use by seasonal residents. Approximately 42% of the developed and undeveloped parcels in the Methow Basin are estimated to be under absentee ownership (inferred from zip codes in the County Assessors database). Most of the developed parcels belonging to seasonal residents are assumed to be located outside town boundaries and serviced by exempt wells. Assuming that 42% of developed parcels are owned by seasonal residents, nonresident population equals 4,295 people. This is equivalent to an additional 1,579 exempt wells potentially in use in seasonal or vacation homes in the Methow. Lacking estimates of seasonal resident water use factors for exempt wells, it is assumed that seasonal residents have per capita uses the same as those of permanent residents. An estimate of the number of seasonal resident exempt wells by sub-basin is presented in Table 10-12.

Per capita Rates of Water Use

Per capita rates of water use were estimated by Ecology in 1991 based on statewide averages used by WDOH and the maximum exemption allowed by law (5,000 gallons per day). These estimates were questioned by EMCON (Ecology, 1991) and revisions were suggested to incorporate "continuity" or return flow to streams (e.g., consider consumptive uses only).

For purposes of this water use assessment, a more likely estimate of exempt well use has been made based on the base and peak municipal water use measured for the Town of Twisp. The Town of Twisp data can be used to estimate consumptive residential water use because the discharge data from the treatment plant is representative of non-consumptive residential water use (assuming leakage in the water supply and wastewater systems is minimal).

Table 10-13 summarizes per-capita domestic use estimates for exempt wells. Actual exempt well water use likely varies depending on whether a secondary irrigation source (e.g., ditch diversions) is available to a household with an exempt well. Existing data estimating per capita exempt well water use for homes with a secondary irrigation supply are not currently available.

Forest Water Use

No comprehensive studies or data are available on water use by forested land in the Methow. However, data from studies in other areas are considered relevant for estimating forest water use.

- Species distribution and basal area for the Okanogan National Forest was determined in 1990 by the US Forest Service (Table 10-14).
- Annual consumptive use by tree species found in the Methow was studied at the Rocky Mountain Forest Research Center in Colorado (Table 10-15).
- Seasonal allocation of annual consumptive use for Douglas fir in the Cedar River Watershed (Fritschen et. al., 1997). Similar studies of eastern Cascade forests could not be located. The seasonal allocation of transpiration rates from Fritschen is shown on Table 10-16.

These data can be used to estimate total annual consumptive use from forested lands.

10.5 Current Water Use

Tables 10-17 through 10-23 provide detailed breakdowns on water use. A summary of annual consumptive water use by sub-basin is located in Table 10-24. Data presented in this section is used in the annual and monthly water balance located in Chapter 12.

10.5.1 Agricultural Water Use

Table 10-17 summarizes the annual crop water use by sub-basin and crop type. These values for crop water use do not include water loss from irrigation canal leakage or on-farm inefficiencies, and are considered to be indicative of consumptive use.

Table 10-18 summarizes total on-farm irrigation requirements using the efficiency ranges typical of sprinkler systems.

10.5.2 Domestic Water Use

Table 10-19 summarizes municipal, residential and exempt water use in the Methow, based on water use data for the town of Twisp. Consumptive municipal use in the basin is estimated to be 211 AF/year, equivalent to an average daily per capita usage of 143 gpdpc. Non-consumptive municipal water use is estimated at 135 AF/yr year, equivalent to an average daily per capita usage of 92 gpdpc. Total water use therefore equals 346 AF/yr, equivalent to an average daily per capita usage of 235 gpdpc.

Total water use by persons on exempt wells, including permanent and seasonal populations, is 2,201 AF/yr. 860 AF is non-consumptive and the remaining 1,340 AF/yr is consumptive. Exempt well use therefore exceeds municipal residential use by a factor of 6.

Total exempt well water use by full time residents in the Methow is estimated at 1,138 AF/yr, of this amount 445 AF/yr is for non-consumptive, year round uses. The remaining 693 AF/yr is consumptive, and is primarily used for outdoor purposes during the summer months.

Total exempt well water use by seasonal non-residents in the Methow is estimated at 1,063 AF/yr, of this amount 416 AF/yr is non-consumptive, year-round use. The remaining 647 AF/yr is considered a consumptive use, and is used primarily for outdoor purposes during the summer months. Exempt use by seasonal residents is therefore approximately equal to full-time residential use.

Table 10-20 presents average residential water use factors by month and by year, that were used to calculate residential water use in the basin. It is assumed that municipal residential water use factors derived from Town of Twisp municipal data can be applied to residential water used by exempt well owners. This is a reasonable assumption for permanent residents, but may overestimate water use by seasonal populations with exempt wells.

Table 10-21 presents a comparison of three domestic water use scenarios:

1. The total permanent population (including municipally supplied and exempt well users) uses water monthly in volumes as described by the Town of Twisp.
2. The total permanent population (including municipally supplied and exempt well users), as well as seasonal populations use water monthly in volumes as described by the Town of Twisp.
3. The total permanent municipally supplied population as well as seasonal populations use water in volumes as described by the Town of Twisp. Permanent residents supplied by exempt wells use the legal limit of available water (5000 gallons per day per household). 2.54 people are assumed to reside in each household.

10.5.3 Water Use – Forest Vegetation

Estimates of forest water use are presented in Table 10-22. The estimate is based on basal area distribution by species type (USFS, 1990), sub-basin species breakdown (USFS, 1999), and annual evapotranspiration rates for several tree species. The tree species in the watershed were grouped into 6 groups Douglas Fir, pine, spruce, deciduous, shrub/herbaceous, and mixed forest for water use estimation purposes, with Douglas Fir consuming the most water and pine (Lodgepole pine) the least. Total consumptive water use by forest species is estimated at 1,404,757 AF/yr. Consumptive water use by Douglas Fir is more than 66 percent of the water consumed by forest species.

Table 10-23 presents a comparison of forest composition changes on total water use estimates. The comparison was completed by assuming that the predominant forest species changed from “fir” to “pine”.

10.6 Future Water Use

Estimates of future water use are a required component for Phase II Watershed Planning under HB2514. In estimating future water use over a 50 year planning horizon, assumptions must be made regarding the conversion of agricultural land to residential land use, growth and zoning changes in the basin.

Okanogan County intends to update its Comprehensive Plan in the near future. The new County Comprehensive Plan, when complete, will likely provide clear direction and policy regarding future growth and zoning, both of which affect overall water use in the basin. At this time, however, the calculation of future water use over a 50-year planning horizon is based on land use assumptions developed by the Methow Basin Planning Unit (MBPU) and shown in Section 9, Table 9-15. If, and when those assumptions change, the water use factors used in this estimate of future water use can be applied to the new land use assumptions.

Table 10-25 summarizes future water use estimates by sub-basin for each water use category (e.g., municipal, agricultural, forest, and exempt wells). These estimates of future water use assume that the number of acres of irrigated agriculture remains the same over the next 50 years; however, 14,000 acres of dry land agriculture are assumed to be converted to 5 acre zoned residential parcels on exempt wells. Furthermore, it is assumed there is no appreciable growth in municipal residential or commercial water demand in the Towns of Twisp and Winthrop or in Group A and B water systems given current Ecology regulations. The acreage of public and private forested lands is also assumed to remain constant. Lastly, it is assumed that 5 acre minimum zoning is applied to all currently developable land in the basin.

In summary, the assumptions used for this example estimate of future basin water use indicate that there is no appreciable difference in water use from irrigation or forested lands between 2002 and 2050; however, the number of exempt well users increases significantly (by 480 percent). For this future use example, increases permanent residential and seasonal residential exempt well use drive the differences in basin wide water use between 2000 and 2050, however, these differences result in only 0.22 % of the total overall basin water use.

It should be noted that full build-out as assumed for this example may be limited by the "2 cfs rule" (Chapter 173-548 WAC) wherein Ecology set a 2.0 cubic feet per second limit on surface water withdrawals for future single domestic and stock water allocation from each of seven primary reaches of the basin. This limitation is discussed in more detail in Section 11.

TABLE 10-1

Generalized Changes in Hydrology Water Balance Components,
Resulting From Forest Coverage Alteration

	Increase In Forest Coverage	**Decrease In Forest Coverage**
Soil Moisture	Decrease	**Increase**
Snow Accumulation	Decrease	**Increase**
Runoff	Decrease	**Increase**
In Stream flow	Decrease	**Increase**
Groundwater Recharge	Decrease	**Increase**
Plant Water Storage	**Increase**	Decrease
Transpiration	**Increase**	Decrease
Interception	**Increase**	Decrease
Evaporation	**Increase**	Decrease

TABLE 10-2

Summary of Historical Irrigation Diversion Estimates and Consumptive Use in the Methow Basin
Source: USGS, 1953

Period	**Acres Above Twisp**	**Use Above Twisp (AF)**	**Acres Above Pateros**	**Use Above Twisp (AF)**	**Total Acres**	**Total Use (AF)**	**Total Use (cfs)[a]**
1890-1905	626	1,096	6,100	10,675	6,726	11,771	35.3
1906-1920	6,780	11,865	11,590	20,283	18,370	32,148	96.4
1921-1930	6,457	11,300	12,120	21,210	18,577	32,510	9705
1931-1940	6,313	11,048	12,540	21,945	18,853	32,993	99.0
1941-1946	7,410	12,968	12,830	22,453	20,240	35,420	106.4

Note: a) Assumes an irrigation period of 168 days,May 1st – October 15th.
Use represents net consumptive use and was calculated using a consumptive use rate of 1.75 acre-feet per acre.

TABLE 10-3

Methow Basin Irrigation Ditches and Estimated Diversion Rates (in cfs)

Ditch Name	Sub-Basin	Length (Miles)	1942[1]	1971 - 1977[6]	1989 – 1993[2]	1991[4]	2000[5]
Aspen Meadows	Twisp	2				1.8	1.3
Barkley	Middle Methow	4.2				12-18	
Beaver	Lower Methow						14
Black Canyon	Lower Methow						1
Buttermilk	Twisp	1.2					3
Chewuch	Chewuch to Middle Methow	12	24-57			17-30	26-30
Early Winters	Methow Headwaters	5				13-15	12-20
Eightmile	Chewuch	1	5.9			6.6-7.2	2.5
Foghorn	Upper Methow	5.4				10-15	18
Foster	Upper Methow						3
Fulton	Chewuch to Middle Methow	4	15-23			17-27	16-22
Gold Ck - Campbell	Lower Methow		4.8				0.5
Gold Ck - Crevlin	Lower Methow						1.5
Gold Creek - Umberger	Lower Methow					1	1.0
Hottell	Twisp	0.2					1.3
Kumm-Holloway	Upper Methow	2.24				1-2	4
Libby/Larson	Lower Methow						2
Mason	Chewuch						0.5
McFarland Creek	Lower Methow		1				0.5
McKinney Mountain	Upper Methow	3.8				2-6	3
MVID East	Middle to Lower Methow	15.5			36-47	36-38	20-24
MVID West	Twisp to Lower Methow	12.5			25-28	22-30	29
Rockview	Upper Methow	5				4-39	6
Skyline	Chewuch	6.2				15-22	17
Twisp Power (TVIPI)	Twisp	4				8-9	13
Wolf Creek	Middle Methow	5				6-8	6-8
Willis[8]	Early Winters					1.1-2.4[8]	
Lower Methow[7]				5.8			
Above Twisp[7]				61.5			
Above Winthrop[7]				93.8			
Chewuch[7]				87			

(1) Miscellaneous Streamflow Measurements in the State of Washington (1890 to 1961)
(2) Miscellaneous Streamflow Measurements in the State of Washington (1961-1985)
(3) Methow Valley Irrigation District
(4) Larson and Peterson (1991) [Washington Department of Ecology]
(5) Golder Associates, 2000. Personal communications with ditch owners
(6) Pacific Northwest Commission, 1977.
(7) Estimates of total diversions for that section of river
(8) Shut down (MBPU, personal communication, 2002)

TABLE 10-4

USGS 2001 Seepage Loss Test

Location	Station (feet)	Length (feet)	Flow (cfs)	Loss (cfs)	Rate (cfs/mile)
Chewuch Canal					
Below Headgate	1,067		41.85		
Above Lundgren Farm	3,175	2,108	41.02	0.83	2.09
Below Lundgren Farm	5,857	2,682	36.45	4.57	9.00
Below Road Crossing	15,600	9,743	31.74	4.71	2.55
Red Dog Road	20,700	5,100	28.66	3.08	3.19
Dempsey Drop	28,440	7,740	25.95	2.71	1.85
McAuliffe's Property	42,370		14.49		
Above Bear Creek Spill	51,000	8,630	11.74	2.76	1.69
Below Bear Creek Spill	51,000		10.09		
Weir Box at End	59,562	8,562	4.29	5.80	3.58
Fulton Creek					
Below Head Gate	100		16.18		
Above Siphon Inlet	1,900	1,800	14.47	1.71	5.02
At Duck Brand Inn	3,300	1,400	13.55	0.91	3.45
At Washington Street	8,400	5,100	13.94	-0.39	-0.40
At Eastside Road	11,400	3,000	11.16	2.78	4.89
Above Bear Creek Spill	16,700	5,300	8.16	3.00	2.98
Below Bear Creek Spill	16,700		5.87		
Weir at End	20,600	3,900	4.43	1.44	1.95

Source: USGS, 2002

TABLE 10-5

Estimated Irrigation Transfers Between Sub-basins

System	Transfer Rate (cfs)
Chewuch to Middle Methow	30
Twisp to Lower Methow	29
Middle Methow to Lower Methow	30
Methow Headwaters to Upper Methow	3

TABLE 10-6

Crop Irrigation Requirements (CIR) Estimates
for Crops Grown in the Methow Basin

Crop	Estimated CIR(CU-EPG -EPD) (inches/yr.)			
	2 Year Return Period	5 Year Return Period	10 Year Return Period	20 Year Return Period
Alfalfa	25	27	27	28
Clover	28	30	31	31
Pasture	26	28	29	30
Grain	23	25	25	26
Apples w/cover	32	34	35	35
Pears w/cover	30	32	32	33
Apples wo/cover	25	26	26	27
Pears wo/cover	33	23	23	24

Source: "Irrigation requirements for Washington - Estimates and methodology" Agricultural Research Center, W.S.U., 1982.

Notes:
- Crop Irrigation Requirement (CIR) for representative crops in the Methow.
- CIR = CU - EPG - EPD
  - CU = Crop Consumptive Use
  - EPG = Growing Season Effective Precipitation
  - EPD = Dormant Season Effective Precipitation (Assumed To Be Zero)
- The return periods of 2, 5, 10, 20 years corresponds to irrigation being adequate for crops for 1 out of 2 years, 4 out of 5 years, 9 out of 10 years, and 19 out of 20 years respectively.
- The Winthrop station was taken to be the representative station for the Methow watershed.

TABLE 10-7

Estimated Distribution of CIR for the Methow Basin

	Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
USGS[1]	Alfalfa	0%	0%	1%	10%	19%	16%	22%	19%	12%	2%	0%	0%
	Pasture	0%	0%	0%	5%	14%	17%	24%	22%	13%	5%	0%	0%
	Grains	0%	0%	0%	1%	8%	21%	29%	24%	17%	0%	0%	0%
	Orchards	0%	0%	0%	3%	13%	21%	26%	22%	13%	3%	0%	0%
	Average			**0%**	**5%**	**13%**	**19%**	**25%**	**22%**	**14%**	**2%**	**0%**	**0%**
WSU[2]	**Crop**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	Alfalfa	3%	3%	3%	3%	13%	13%	13%	13%	13%	13%	3%	3%
	Pasture	3%	3%	3%	3%	13%	13%	13%	13%	13%	13%	3%	3%
	Apples w/cover	2%	2%	2%	2%	11%	16%	17%	17%	16%	13%	2%	2%
	Average	**3%**	**3%**	**3%**	**3%**	**12%**	**14%**	**15%**	**15%**	**14%**	**13%**	**3%**	**3%**

Source: 1) *The Water Resources of the Methow Basin*, July 1976, Office Report 56
2) *Irrigation requirements for Washington - Estimates and methodology"*, September 1989, Washington State University- Cooperative Extension, Pullman, EB 1513

TABLE 10-8

MAPA Project Irrigated Acreage by Crop Type

Sub-basin	**Crop Type**			
	Alfalfa (Acres)	**Orchard (Acres)**	**Pasture/Turf (Acres)**	**Total (Acres)**
Chewuch	918	26	514	1,458
Early Winters	--	--	--	--
East Lower Methow	3,728	699	319	4,747
Methow Headwaters	557	--	192	749
Middle Methow	2,503	55	391	2,949
Twisp	1,036	52	199	1,287
Upper Methow	2,173	--	382	2,554
West Lower Methow	1,952	741	293	2,985
Total	12,868	1,572	2,288	16,729

Source: Methow Air Photo Assessment Project (MAPA Project), 1995
Note: Areas designated as “currently irrigated” only

TABLE 10-9

Typical Overall On-farm Efficiencies (Including Application and Distribution Efficiency) for Various Irrigation Systems[1]

System type	Overall efficiency (%)
Surface:	
a). Average	50
b). Land leveling, pipe water delivery meeting design standards	70
c). Tailwater recovery with (b)	80
d). Cut-back irrigation	80
e). Surge	70 - 90[2]
Sprinkler	50 - 75[3]
Center Pivot - equipped with:	
a). Impact sprinklers	50 - 60
b). Low pressure drops	75 - 85[3]
c). LESA (low elevation spray application)	85 - 95
d). LEPA (low energy precision application)	85 - 95
Drip	80 - 90[4]

[1] Fipps 1998-freely adapted from James, 1988.
[2] surge increases efficiencies from 8 - 28% over non-surge furrow systems
[3] under low wind weather conditions
[4] drip systems are typically designed at these efficiencies. However, short laterals and/or pressure compensating emitters may have higher efficiencies, and excessively long laterals will have lower efficiencies.

TABLE 10-10

Average Historic Pumping and Discharge Data for the Town of Winthrop

	Average Water Pumped (AF)	Average Wastewater Discharged (AF)
January	15	5
February	14	5
March	14	4
April	15	4
May	25	5
June	26	5
July	30	6
August	31	6
September	23	5
October	15	4
November	11	3
December	16	4
Total	235	53

TABLE 10-11

Public Water System (PWS) Summary By Sub-Basin

Sub-basin	Group A PWS	Group B PWS
Chewuch	16	33
Early Winters	3	3
East Lower Methow	1	0
Methow Headwaters	9	25
Middle Methow	5	0
Twisp	0	0
Upper Methow	4	19
West Lower Methow	7	2
Watershed Total	45	82

Note: All classifications of PWSs are included in the table: community (COMM), transient non-community (TNC), and non-transient non-community (NTNC) water systems.

TABLE 10-12

Estimated Number of Single Domestic, "Exempt Well", Users in the Methow River Basin

Sub-Basin	Ecology Estimate of Exempt Wells[1]	2000 Permanent Population	2000 Permanent Population on Exempt Wells	Exempt Wells Used by Permanent Residents[2]	Exempt Wells Used by Seasonal Residents[3]	Total Number of Exempt Wells (permanent and seasonal use)
Chewuch	214	506	389	153	134	287
Early Winters	0	40	40	16	2	18
East Lower Methow	447	1,432	1,114	438	360	798
Methow Headwaters	50	124	124	49	11	60
Middle Methow	230	948	831	327	319	646
Twisp	110	886	568	223	337	560
Upper Methow	96	413	296	117	69	186
West Lower Methow	--	1,251	933	367	347	714
Total	1,147	5,600	4,295	1,691	1,579	**3,270**

Source: 1) Washington Department of Ecology, December 1991
2) Estimate based on 2000 population.
3) Estimate inferred from absentee ownership of parcels in the Okanogan Assessors database, based on zip code.

TABLE 10-13

Estimated Annual Use for Single Domestic Exempt Wells in the Methow River Basin (per Household)[1]

Methodology	Exempt Well Estimate	Total Use				Consumptive Use				Source	Year of Estimate
		Low		High		Low		High			
		cfs	gpd	cfs	gpd	cfs	gpd	cfs	gpd		
Estimate(includes consumptive and non-consumptive use)	1,101			0.0075	4,847	--		--		WA Department of Ecology	1990
Continuity Corrected	1,101					0.00016	103	0.002	1,293	Sweet-Edwards/EMCON	1991
Estimate(includes consumptive and non-consumptive use)	1,147	0.0007	450	0.007	4,496	--		--		WA Department of Ecology	1991
Twisp Consumptive Winter Use [2]	3,223					0.00009	58	0.00028	182	Golder Associates, Inc.	2002
Twisp Consumptive Summer Use[2]	3,223					0.00041	264	0.00141	909	Golder Associates, Inc.	2002

Note: 1) Use estimates expressed as per household. Per capita (per person) use is less.
2) Assumes 2.54 people per household (Domestic Use), Winter use = October – March, Summer use = April – September. Calculations based on metered diversion and discharge records for the Town of Twisp.

TABLE 10-14

Distribution of Samples by Total Stand Basal Area Per Acre – Okanagon National Forest. Expressed in Percent for Each Species
Basal Area (sq ft/acre)

Species Code	0-50	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400+
West. White Pine	0	0	0	0	0	0	0	0	0
Western Larch	5	21	29	17	11	9	6	<1	2
Douglas-Fir	14	23	22	14	11	7	5	2	2
Pacific Silver Fir	4	8	6	13	19	22	14	7	6
West. Red Cedar	0	0	0	0	0	0	0	0	0
Grand Fir	5	15	20	18	18	15	5	3	5
Lodgepole Pine	10	21	34	20	9	4	1	1	<1
Engelmann Spruce	2	10	17	29	22	12	7	1	<1
Subalpine Fir	1	10	19	25	28	10	6	1	<1
Ponderosa Pine	14	35	29	14	5	2	<1	<1	0
Mt. Hemlock/Other	6	12	11	14	16	20	11	5	4

Source: Johnson, R.R., May 14, 1990, *East Cascades Prognosis Geographic Variant of the Forest Vegetation Simulator,* WO-TM Service Center, USDA-Forest Service

TABLE 10-15

Consumptive Use of Tree Species in the Rocky Mountains, Colorado

Tree Species	Estimated Consumptive Use (mm/Yr)			Length of Transpiration Season (days)
	Basal Area 10 (m2/ha)	Basal Area 20 (m2/ha)	Basal Area 30 (m2/ha)	
Engelmann Spruce	125	248	373	227
Sub-Alpine Fir	86	---	---	227
Lodgepole Pine	73	145	220	227
Aspen	100 to 300			110

Source: Alexander, R.R., et al, 1985 *The Fraser Experimental Forest, Colorado: Research Program and Published Research 1937-1985,* USDA Forest Service, General Technical Report RM-119.

TABLE 10-16

Evapotranspiration of a Douglas Fir, Cedar River, Washington
(daily in millimeters)

Month	1972	1973	1974	Normalized Average
January	0.3			2%
February	0.3			2%
March	0.3			2%
April	1.55		2.01	10%
May	2.19		2.46	13%
June	2.12	2.79	2.72	14%
July	2.09	1.85	2.72	12%
August	2.75	1.91	3.64	15%
September	1.74	1.7	2.66	11%
October	1.3	1.76	1.29	8%
November	1.27	2.68		11%
December	0.3			2%

Note: ET rates from Jan through March are assumed to be equivalent of those in December, since no data were collected during those months.
Source: Fritschen, et. al., 1997.

TABLE 10-17

Crop Water Use by Sub-basin and Crop Type

	Total (Acres)	Percent of Sub-basin	Alfalfa (acre-ft/yr)	Orchard (acre-ft/yr)	Pasture/Turf (acre-ft/yr)	Total (acre-ft/yr)	Total (cfs)
Chewuch	1,458	0.44	2,066	74	1,199	3,339	10
Early Winters	0	--	--	--	--	--	--
East Lower Methow	4,746	2.96	8,388	1,981	744	11,113	33
Methow Headwaters	769	0.42	1,298	0	448	1,746	5
Middle Methow	2,949	8.23	5,632	156	912	6,700	20
Twisp	1,287	0.82	2,331	147	464	2,943	9
Upper Methow	2,555	2.90	4,889	0	923	5,812	17
West Lower Methow	2,986	1.92	4,392	2,100	684	7,175	22
Watershed Total	16,750	1.45	28,996	4,457	5,375	38,828	116

Note: Indicates crop consumptive use and does not include on-farm or irrigation transportation losses. Irrigated acreage based on MAPA orthophoto analysis (Ecology, 2002).

TABLE 10-18

Total On-Farm Irrigation Requirement

Sub-Basin	50 % Efficiency		60 % Efficiency		70 % Efficiency	
	Total (acre-ft/yr)	**Total (cfs)**	**Total (acre-ft/yr)**	**Total (cfs)**	**Total (acre-ft/yr)**	**Total (cfs)**
Chewuch	6,677	20	5,564	17	4,769	14
Early Winters						
East Lower Methow	22,226	67	18,521	56	15,875	48
Methow Headwaters	3,493	10	2,910	9	2,495	7
Middle Methow	13,400	40	11,167	33	9,571	29
Twisp	5,885	18	4,904	15	4,204	13
Upper Methow	11,625	35	9,687	29	8,303	25
West Lower Methow	14,350	43	11,959	36	10,250	31
Total	77,656	233	64,713	194	55,468	166

Note:

1) Includes on farm use only and does not include conveyance losses.
2) Crop Irrigation Requirement for each crop is representative of a 5-year return period.
3) 50 percent efficiency representative of as simple impact sprinkler system and surface irrigation.
4) 60 percent efficiency representative of a moderately efficient impact sprinkler system.
5) 70 percent efficiency representative of as efficient impact sprinkler system and surface irrigation with land leveling.

a) Assumes an irrigation period of 168 days, May 1st – October 15th

TABLE 10-19

Estimated Domestic and Municipal Water Use

Units	Sub-Basin	2000 Methow Population	Municipal Water Use				Residential Exempt Wells				Municipal & Exempt Well Total Water Use
			People Served	Non-Consumptive Water Use	Consumptive Water Use	Total Water Use	People Served	Non-Consumptive Water Use	Consumptive Water Use	Total Water Use	
Acre-Feet/year	Chewuch	506	117	12	19	31	730	76	118	193	224
	Early Winters	40	0	0	0	0	44	5	7	12	12
	East Lower Methow	1,432	318	33	51	84	2,028	210	327	537	622
	Methow Headwaters	124	0	0	0	0	152	16	25	40	40
	Middle Methow	948	117	12	19	31	1,641	170	265	435	466
	Twisp	886	318	33	51	84	1,424	147	230	377	462
	Upper Methow	413	117	12	19	31	472	49	76	125	156
	West Lower Methow	1,251	318	33	51	84	1,815	188	293	481	565
	Total	5,600	1,305	135	211	346	8,306	860	1,340	2,201	2,546
Million Gallons/year	Chewuch	506	117	4	6	10	730	25	38	63	73
	Early Winters	40	0	0	0	0	44	1	2	4	4
	East Lower Methow	1,432	318	11	17	27	2,028	68	107	175	203
	Methow Headwaters	124	0	0	0	0	152	5	8	13	13
	Middle Methow	948	117	4	6	10	1,641	55	86	142	152
	Twisp	886	318	11	17	27	1,424	48	75	123	150
	Upper Methow	413	117	4	6	10	472	16	25	41	51
	West Lower Methow	1,251	318	11	17	27	1,815	61	95	157	184
	Total	5,600	1,305	44	69	113	8,306	280	437	717	830

Notes: 1) All permanent resident figures based on 2000 population data.
2) Exempt wells estimated from 2000 census data and Okanogan Assessors database.
3)Per Capita Water Use based on Town of Twisp 2000 water use records.

TABLE 10-20

Assumed Per Capita Water Use
(Consumptive and Non-Consumptive Use)

Month	Non-Consumptive Water Use (gpdpc)	Consumptive Water Use (gpdpc)	Total Water Use (gpdpc)
January	81	51	132
February	81	51	132
March	81	51	132
April	93	104	197
May	98	201	300
June	108	260	368
July	113	341	454
August	110	358	468
September	101	147	249
October	81	51	132
November	81	51	132
December	81	51	132
Annual	**92**	**143**	**2,828**

Note: 1) Per Capita Water Use based on Town of Twisp 2000 water use records.
2) Consumptive and non-consumptive water use estimates were evaluated from the deferential between water diverted and wastewater discharged to the Methow river.
3) All units in gallons per day per capita (gpdpc)

TABLE 10-21

Comparison of Water Use Estimates

		Annual Acre-ft Of Water Use					
Scenario		Chewuch	Lower methow	Methow Headwaters	Middle Methow	Twisp	Upper Methow
1	Annual	82	433	26	153	143	67
2		137	723	32	284	281	95
3	Annual	165	871	44	344	322	117
% Increase from 1 to 2		67%	67%	20%	85%	97%	43%
% Increase from 1 to 3		102%	101%	64%	125%	125%	75%

Scenario 1: Permanent Population only, per capita use per Twisp (2000)
Scenario 2: Permanent and Seasonal population, per capita use per Twisp (2000)
Scenario 3: Permanent and seasonal population; 5,000 gallons per household (exempt well legal limit) for permanent population and per capita use per Twisp (2000) for seasonal population

TABLE 10-22

Estimated Forest Water Use (acre-ft/yr)

Land Cover	Transpiration Rate (mm/yr)	Chewuch (AF/yr)	Early Winters (AF/yr)	East Lower Methow (AF/yr)	Methow Headwaters (AF/yr)	Middle Methow (AF/yr)	Twisp (AF/yr)	Upper Methow (AF/yr)	West Lower Methow (AF/yr)	Total (AF/yr)
Douglas Fir	560[2]	273,556	42,673	86,840	148,620	11,746	148,421	75,922	140,365	928,143
Pine	250[1]	91,025	4,087	26,532	18,041	5,002	19,118	13,013	22,080	198,898
Spruce	500[1]	6,743	1,252	515	7,780	55	1,798	639	1,968	20,749
Deciduous (aspen)	300[1]	2,341	246	1,183	1,441	719	3,255	2,121	2,181	13,488
Shrub/Herbacious	310[2]	25,182	2,404	56,187	14,680	11,785	14,154	13,651	31,476	169,519
Mixed Forest	430[3]	11,905	6,307	14,180	31,778	407	5,065	2,334	2,983	74,959
Total	**1,920**	**410,752**	**56,969**	**185,437**	**222,340**	**29,714**	**191,811**	**107,681**	**201,053**	**1,405,757**

Note: 1) Source: USDA Forest Service Rocky Mountain Forest and Experiment Range Station, GTR RM-118, 1985
2) Source: Waring, R. H., 1985, Forest Ecosystems, Academic Press, Inc, UK, London
3) Taken to be 50% Douglas fir and 50% deciduous trees.

TABLE 10-23

Comparison of Annual Forest Water Use Due to Varying Forest Composition (acre-ft)

	Chewuch	Early Winters	East Lower Methow	Methow Headwaters	Middle Methow	Twisp	Upper Methow	West Lower Methow	Total
Forest Composition from USDA Forest Service, 1999	410,752	56,969	185,437	222,340	29,714	191,811	107,681	201,053	1,405,757
Assuming all fir trees are replaced with Lodgpole Pine	255,028	31,073	132,253	128,614	23,065	107,823	64,811	122,276	864,943
Percent change from USDA forest composition water use	-38%	-45%	-29%	-42%	-22%	-44%	-40%	-39%	-38%

TABLE 10-24

Total 2000 Annual Consumptive Water Use by Sub-Basin, in Acre-Feet

Sub-Basin	Municipal - Residential	Exempt Wells[1]	Agricultural[2]	Forest	Total Water Use
Chewuch	19	193	4,769	410,752	415,697
Early Winters	0	12	--	56,969	56,981
East Lower Methow	51	537	15,875	185,437	201,806
Methow Headwaters	0	40	2,495	222,340	224,874
Middle Methow	19	435	9,571	29,714	39,640
Twisp	51	377	4,204	191,811	196,332
Upper Methow	19	125	8,303	107,681	116,114
West Lower Methow	51	481	10,250	201,053	211,738
Total	**211**	**2,201**	**55,468**	**1,405,757**	**1,463,184**
% of Total Water Use	**0.01%**	**0.15%**	**3.8%**	**96.1%**	

Note: 1) Includes both resident and seasonal populations.
2) 70 percent irrigation efficiency was used and is representative of a moderately efficient impact sprinkler system.
3) Tables 10-17, 10-18 and 10-20 provide a detailed breakdown.

TABLE 10-25

Total Projected (2050) Consumptive Water Use by Sub-Basin, in Acre-Feet per year

Sub-Basin	Municipal - Residential	Exempt Wells[1]	Agricultural[2]	Forest	Total Water Use
Chewuch	19	--	4,769	410,752	415,540
Early Winters	0	--	--	56,969	56,969
East Lower Methow	51	--	15,875	185,437	201,363
Methow Headwaters	0	--	2,495	222,340	224,835
Middle Methow	19	--	9,571	29,714	39,304
Twisp	51	--	4,204	191,811	196,066
Upper Methow	19	--	8,303	107,681	116,003
West Lower Methow	51	--	10,250	201,053	211,354
Total	**211**	**5,190**	**55,468**	**1,405,757**	**1,466,626**
% of Total Water Use	**0.01%**	**0.35%**	**3.78%**	**95.85%**	

Note: 1) Includes both resident and seasonal populations.
2) 70 percent irrigation efficiency was used and is representative of a moderately efficient impact sprinkler system.
3) Tables 10-16, 10-17 and 10-18 provide a detailed breakdown.