CHAPTER 5. HYDROLOGY AND WATER USE

INTRODUCTION

The subjects of hydrology and water use in the Lower Sprague-Lower Williamson subbasin are complicated, because regional stakeholders are currently involved in contested water rights adjudication. In the attempt to support their respective claims, various stakeholders have produced data and information on hydrology and water use. Some information has been produced by state and federal agencies, some has been produced by tribes, some by private consultants, and some has been compiled by citizens, landowners and advocacy groups. Because each of these entities is a claimant in the ongoing adjudication, the data they have produced are frequently disputed by entities with competing claims.

This Watershed Assessment is built upon the premise that differing opinions regarding natural resources issues should be respected and given voice. It is also built upon the premise that there are many different sources of legitimate information about watershed conditions and functions, and that not all of these sources come in the form of published, peer-reviewed reports prepared by professional scientists. Given these premises, and given the pervasive influence of the adjudication on stakeholders' views with regard to hydrology and water use, the preparation of this chapter demanded a substantial additional investment of time and attention in an attempt to ensure that the information presented did not constitute an inadvertent endorsement or validation of contested information.

It is perhaps inevitable that the information presented in this chapter will be unsatisfactory to some stakeholders involved in the adjudication. It is hoped, however, that the bulk of the information is found to be useful to landowners that are required to make day-to-day management decisions and to stakeholders as they work together to sustain both the natural and human communities in the Lower Sprague-Lower Williamson subbasin.

HYDROLOGY

Limited water availability influences virtually all aspects of stream and watershed health, from water temperature and pool depth to the quality of the habitat for fish and other life forms. It affects agricultural and domestic water uses and constrains human use of the land and enjoyment of the natural resources. Furthermore, water availability concerns will almost certainly be exacerbated if climate projections are realized. Currently, most natural resource management studies do not include a discussion of climate change unless it is the direct focus of the study. However, there is a clear scientific consensus that our climate is warming and that precipitation patterns are changing (IPCC 2001, INR 2004). Such changes are expected to have important effects on natural resource issues in the Lower Sprague-Lower Williamson subbasin.

Current models of the effects of climate change in the Pacific Northwest suggest that maximum snow pack depth will shift to earlier in the year, resulting in earlier maximum stream flow and decreased late-summer flows. Projected population growth is likely to increase water demand at the same time that water availability is projected to be declining (INR 2004). Additional effects may include a lengthening of the growing season, longer fire season, earlier plant flowering and animal breeding, and changes in elevational plant distributions (INR 2004).

Precipitation

The Lower Sprague-Lower Williamson subbasin lies in the semi-arid rain shadow east of the Cascade Mountains. The majority of precipitation falls as snow from October through March. The subbasin receives rain and snow totaling between 15 inches and 42 inches of precipitation each year, depending on elevation, with the highest elevations receiving the greatest depths (OCS 2007). Winter temperatures drop below 0º F. Frost and snow may occur in all seasons at higher elevations. Although summers are dry, they are characterized by intense localized convective thunderstorms.

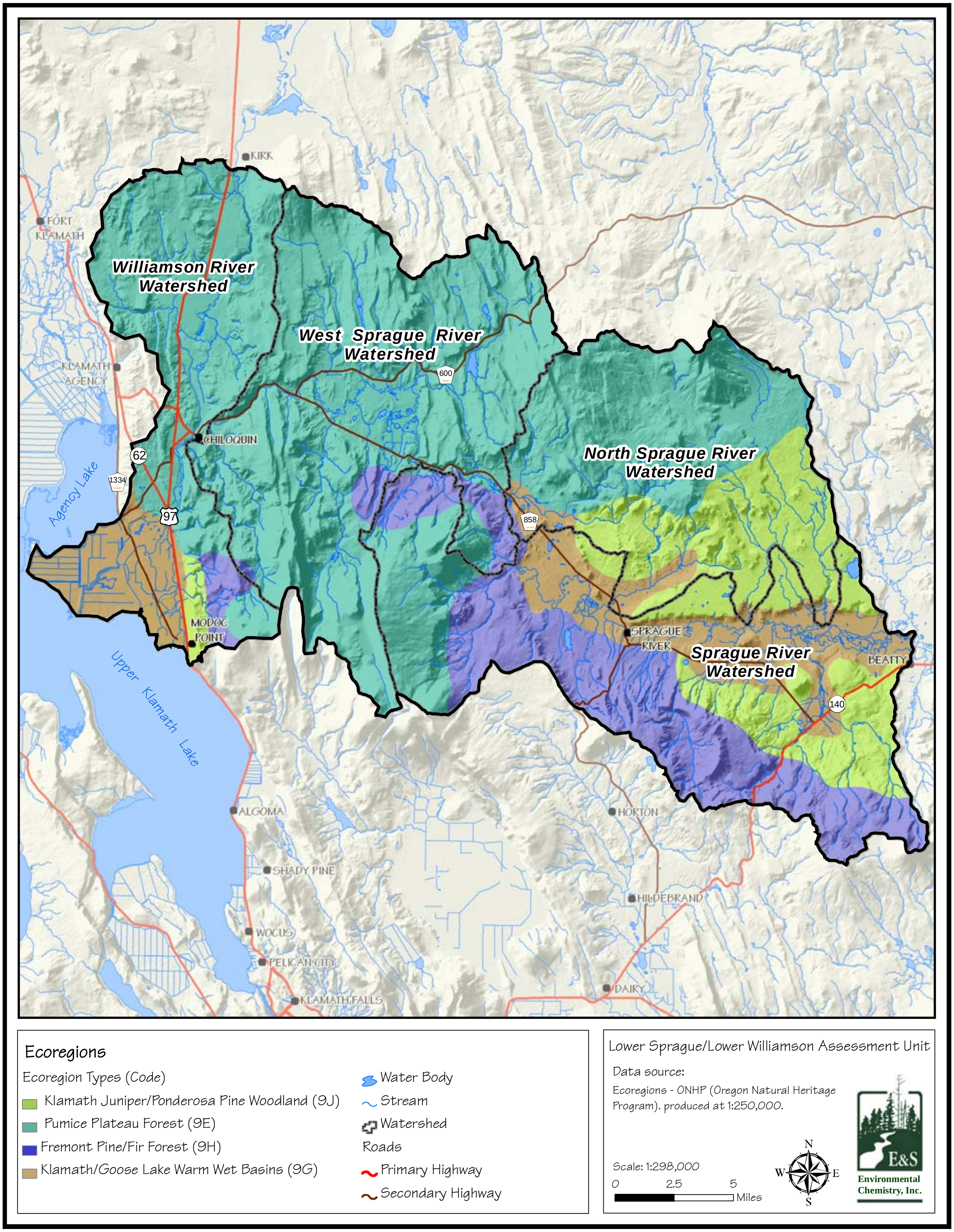
It is important to note that while the majority of precipitation that falls is snow, snow acts much differently than rain in the watershed. Rain results in peak flows and run-off relatively quickly compared to the snow event. In contrast, snow fall does not result in peak flows, runoff and infiltration until the snow melts. Therefore, instead of seeing peak flows and runoff events during the months with the highest precipitation (December through February), peak flows and runoff events are seen in spring, during snowmelt or rain-on-snow events. When the ground is frozen, no infiltration of precipitation or snowmelt will occur. The ground needs to be thawed to allow infiltration. Juniper trees also limit the amount of precipitation that infiltrates, because they catch the precipitation in their canopy. Once captured in the canopy, the precipitation often evaporates before hitting the ground surface and infiltrating (Barrett 2007).

Just because there is an average precipitation year does not mean there is an average water year. The water year is dependent on the timing of the water availability and type of precipitation. An adequate snowpack is needed to ensure an average water year. Lots of rain does not necessarily mean there will be adequate water later in the season (late summer and fall). The late water typically results from snowmelt occurring over a longer season due to a higher snowpack.

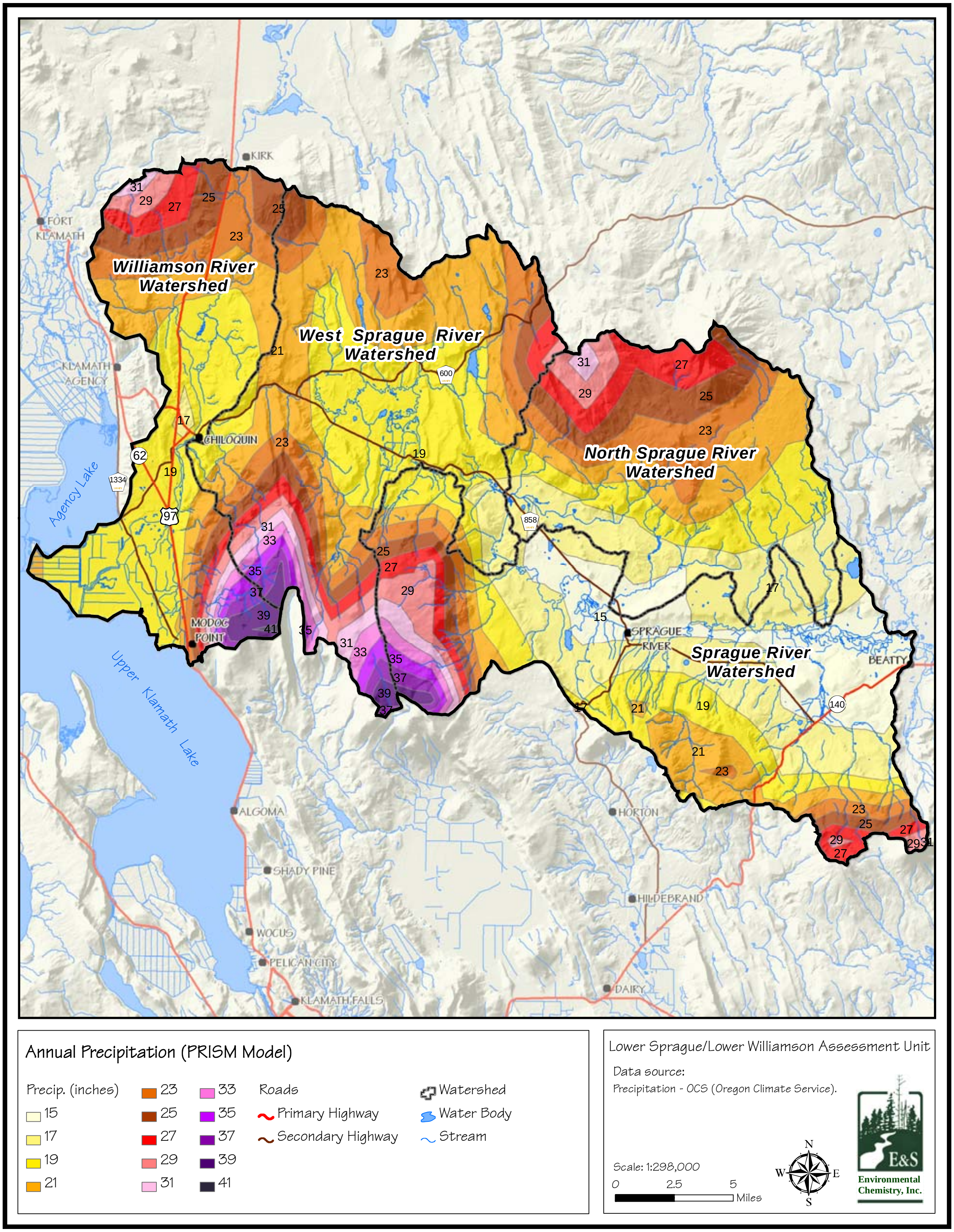
The Lower Sprague-Lower Williamson subbasin contains four watersheds (USGS 5th-field) spanning several ecoregions that vary somewhat in their general hydrologic characteristics (Map 5-1). The ecoregions included in the Lower Sprague-Lower Williamson subbasin and their hydrologic characteristics are listed in Table 5-1. The Pumice Plateau Forest and Fremont Pine/Fir Forest ecoregions experience the highest amounts of precipitation, while the Klamath/Goose Lake Warm Wet Basins and Klamath Juniper/Ponderosa Pine Woodland ecoregions are the driest (Table 5-2; Map 5-2).

Table 5-1 Ecoregions of the Lower Sprague-Lower Williamson subbasin (Data Source: ONHP 1995)

Ecoregion	Area (mi^2)	Characteristics
Fremont Pine/Fir Forest	87.4	Steeply to moderately sloping mountains and high plateaus with high gradient intermittent and ephemeral streams. Reservoirs, a few glacial rock-basin lakes and many springs occur.
Klamath Juniper/Ponderosa Pine Woodland	88.4	Undulating hills, benches and escarpments containing medium gradient streams. A few small plateau lakes occur, but reservoirs are common.
Klamath/Goose Lake Warm Wet Basins	76.0	Pluvial lake basins containing floodplains, terraces and low gradient streams.
Pumice Plateau Forest	347.8	High elevation, nearly level to undulating volcanic plateau with isolated buttes, marshes, spring-fed creeks and streams with low to medium gradients.



Map 5-1 Ecoregions in the Lower Sprague-Lower Williamson subbasin (Data Source: ONHP 1995)



Map 5-2 Modeled annual precipitation for the Lower Sprague-Lower Williamson subbasin, using PRISM
(Data Source: OCS 2006)

There are several types and sources of precipitation information for the Lower Sprague-Lower Williamson subbasin. Continuous precipitation records have been collected in the vicinity of the town of Sprague River, within the Sprague River Valley reach of the study area. These records include some data gaps, but they span a sufficient time period to provide a reliable estimate of average conditions (WRCC 2006). Climatologists at Oregon State University (OSU) have developed the Parameter-elevation Regressions on Independent Slopes Model (PRISM), which estimates average annual precipitation throughout Oregon (OCS 2006). These data are probably best for estimating precipitation amounts. Finally, the Snowpack Telemetry (SNOTEL) program of the Natural Resource Conservation Service (NRCS) collects data on snow accumulation. There are several SNOTEL stations within the subbasin.

Figure 5-1 presents average annual precipitation by year (WRCC 2006). Although the record extends from 1953 through 2001, years in which more than five consecutive days of data are absent in a single month were removed. Average annual measured precipitation at Sprague River is 17 inches and at Chiloquin is 20 inches (Figure 5-1). In some parts of the assessment area, annual average precipitation may be less. Annual precipitation has been below average since 1999, with with 2004 being a slight exception. Average monthly precipitation as measured at Chiloquin is presented in Figure 5-2. December typically has the most precipitation and July/August has the least. Four months, November through February, account for more than half of annual precipitation (WRCC 2006).

PRISM was developed by researchers at OSU to estimate climatological conditions across the state of Oregon (Daly et al. 1994, OCS 2006). The GIS precipitation data available from OSU for the Lower Sprague-Lower Williamson subbasin are shown in Map 5-2. Mean annual precipitation ranges from 15 inches near Beatty to 37 inches in the upper elevations of Swan Lake Point. The average annual precipitation for the subbasin as a whole, as estimated by PRISM, is approximately 25.8 inches, but varies considerably among the constituent watersheds. The precipitation characteristics modeled by PRISM for the watersheds are provided in Table 5-3.

Table 5-2 Hydrologic characteristics of ecoregions within the Lower Sprague-Lower Williamson subbasin
(Data Source: ONHP 1995)

Ecoregion	Code	Precipitation	Precipitation Pattern	Runoff Pattern	Peak Flow
Pumice Plateau Forest	9E	16 to 30 inches	Most precipitation occurs in the winter months from November to January.	Average monthly stream flows are highest in the late spring and early summer months. Some streams also experience high flow values in the fall and winter.	Primarily spring rain-on-snow, spring snowmelt and spring rainstorms; winter rain-on-snow can also produce peak flows, though they are less common.
Klamath/ Goose Lake Warm Wet Basins	9G	10 to 18 inches; up to 40 inches in higher elevations	Most precipitation occurs in the winter months, predominately in November to January.	Average monthly stream flows tend to be slightly higher in winter and spring; many of the streams in this ecoregion experience very little variation in runoff values throughout the year.	Spring snowmelt and summer rainstorms.
Fremont Pine/Fir Forest	9H	15 to 40 inches	Majority of the precipitation occurs during the winter and early spring months from December to April.	Average monthly stream flows tend to be slightly higher in winter and spring, although many of the streams in this ecoregion experience very little variation in runoff values throughout the year.	Spring snowmelt and summer rainstorms.
Klamath Juniper/ Ponderosa Pine Woodland	9J	12 to 20 inches	Most precipitation occurs in the winter months, predominately in November to January.	Average monthly stream flows tend to be slightly higher in winter and spring, although many of the streams in this ecoregion experience very little variation in runoff values throughout the year.	Spring snowmelt and summer rainstorms.

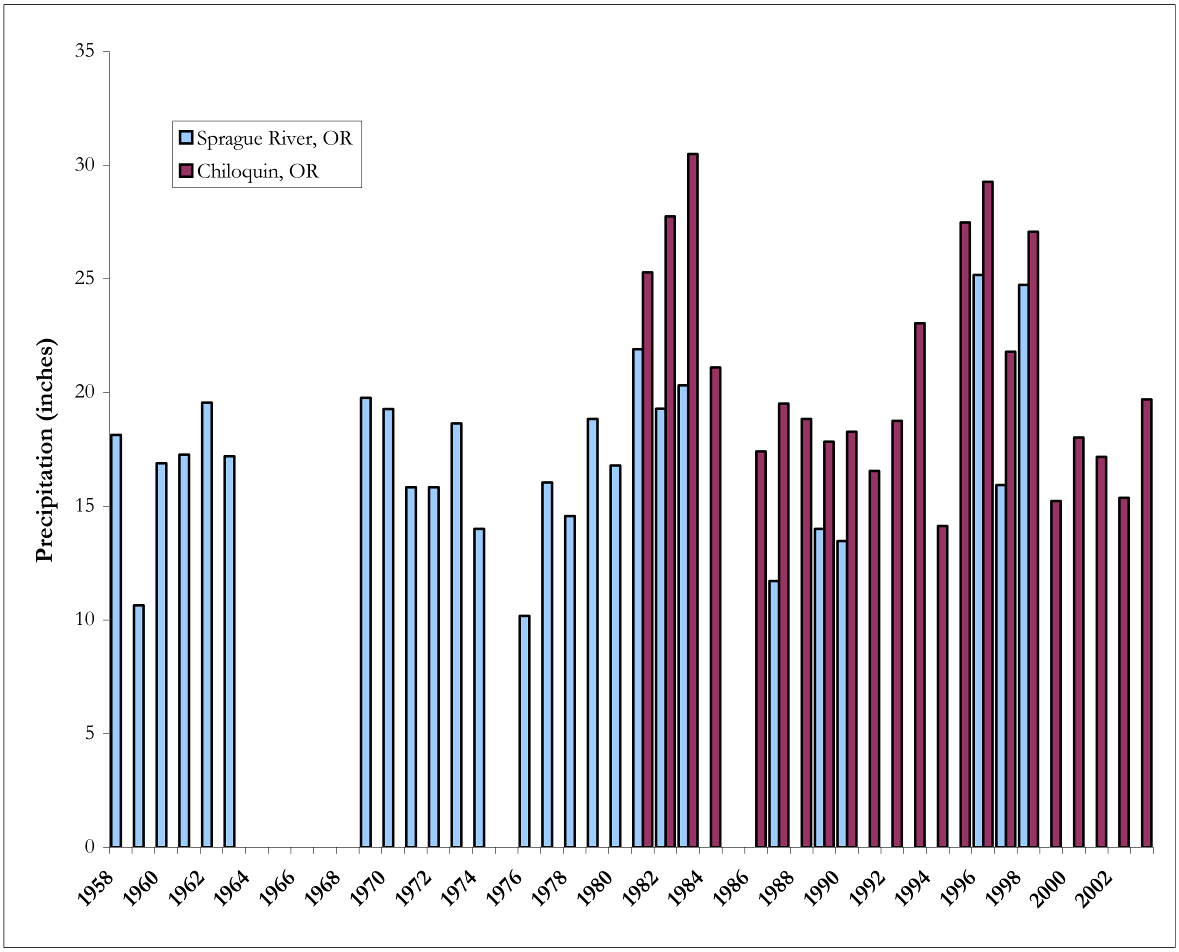


Figure 5-1 Annual precipitation measured at Chiloquin and Sprague River, showing long-term patterns in regional precipitation
(Data Source: WRCC 2006)

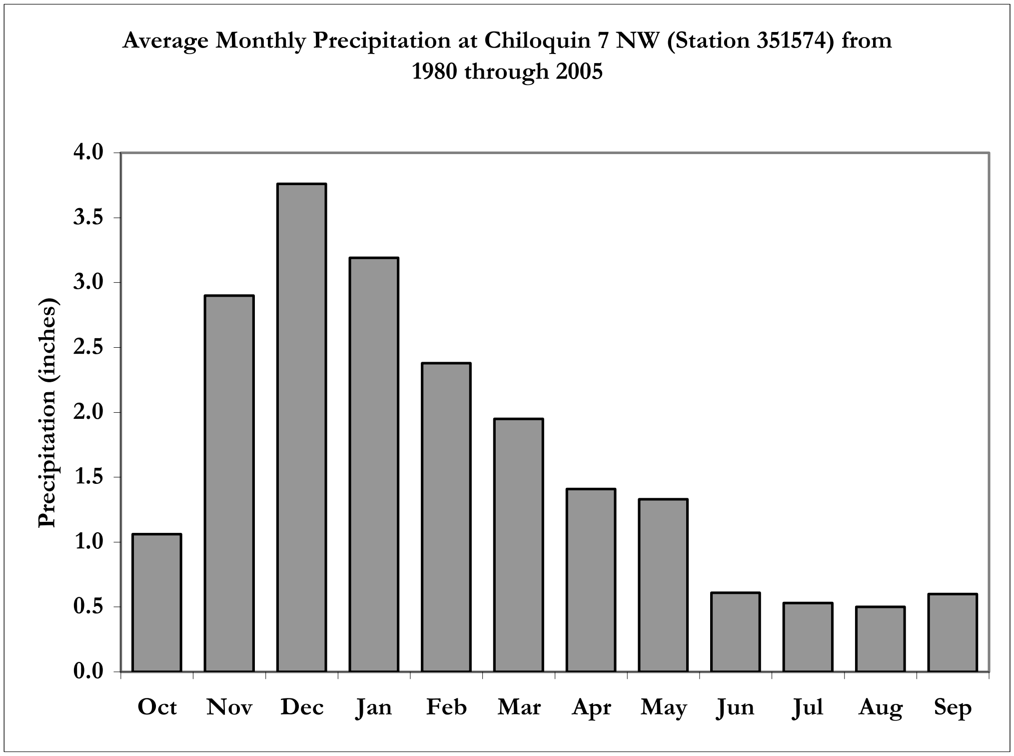
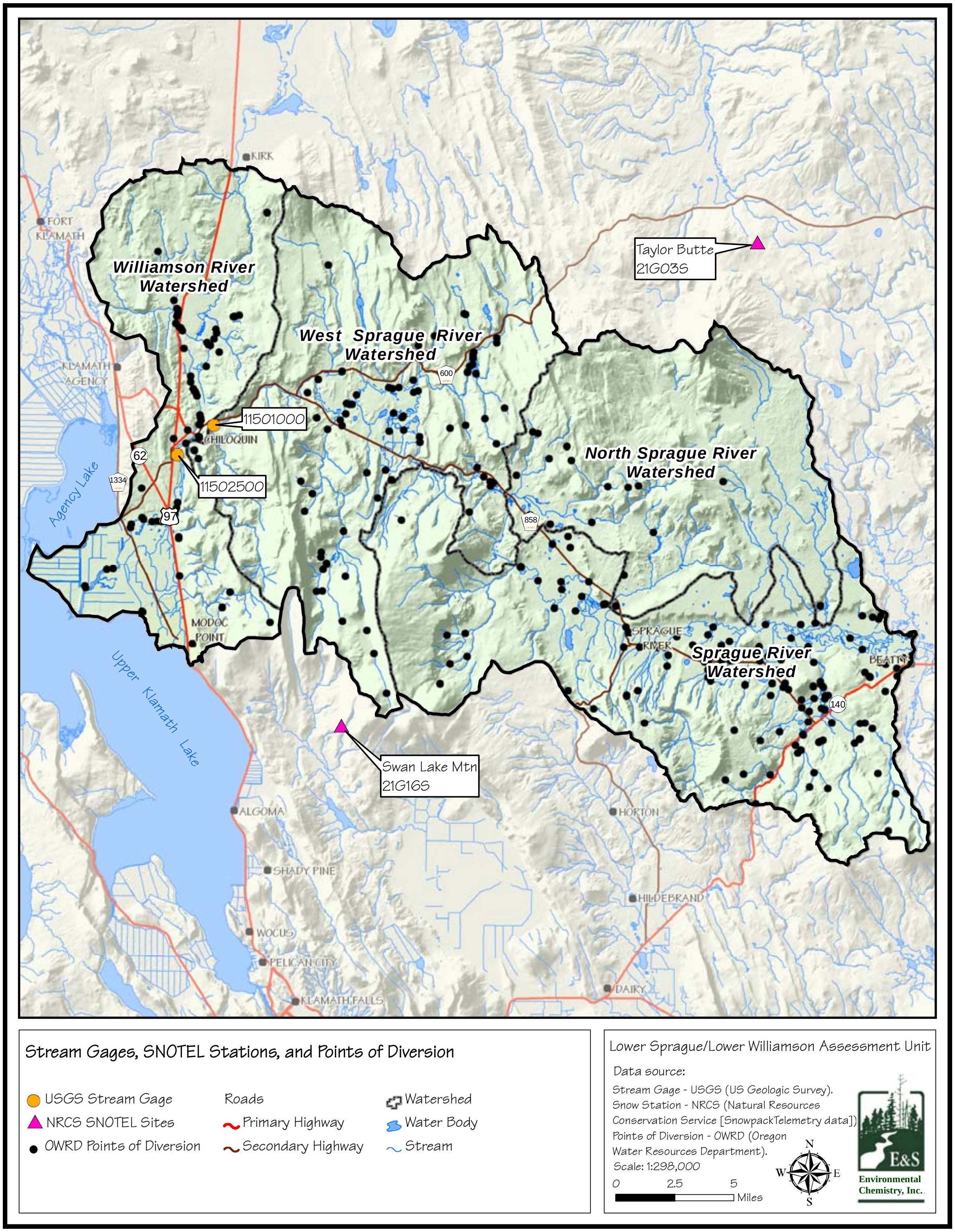


Figure 5-2 Annual distribution of precipitation as shown by average monthly precipitation at Chiloquin, Oregon
(Data Source: WRCC 2006)

Table 5-3 PRISM annual precipitation values for watersheds of the Lower Sprague-Lower Williamson subbasin
(Data Source: OCS 2006)

Watershed	Minimum Precip. (in)	Average Precip. (in)	Maximum Precip. (in)	Minimum Elevation (ft)	Maximum Elevation (ft)	Area (m^2)
North Sprague River	15	21	31	4,278	6,926	123.0
Sprague River	15	25	39	4,265	7,261	183.9
West Sprague River	17	28	41	4,164	7,011	176.0
Williamson River	17	29	41	4,124	6,490	116.7

Winter precipitation typically falls as snow and accumulates throughout the Lower Sprague-Lower Williamson subbasin. Snow pack data were obtained from the Natural Resource Conservation Service (NRCS 2006) for approximately the last 25 years at four SNOTEL snow survey sites near the subbasin. These are listed in Table 5-4, and shown on Map 5-3. Annual snowpack is quite variable from year to year. Figure 5-3 illustrates the peak annual snow pack for the period of record for the Taylor Butte and Cold Springs Camp snow survey sites. Although the greatest amount of precipitation typically occurs in December (based on the Sprague River data), maximum snow accumulation typically occurs in February, as measured at Taylor Butte (Figure 5-3).



Map 5-3 Locations of stream gages, SNOTEL stations, and points of diversion in the Lower Sprague-Lower Williamson subbasin
(Data Sources: USGS 2005, NRCS 2006, OWRD 2007)

[Note: The Cold Springs Camp SNOTEL site is outside the mapped region but is included in this figure because of its proximity to the subbasin. This SNOTEL site is located in a high zone area of the southern Cascades and most likely overestimates the snow amounts within the watershed assessment area. The Swan Lake SNOTEL site has only one data year and is not included in this figure.]

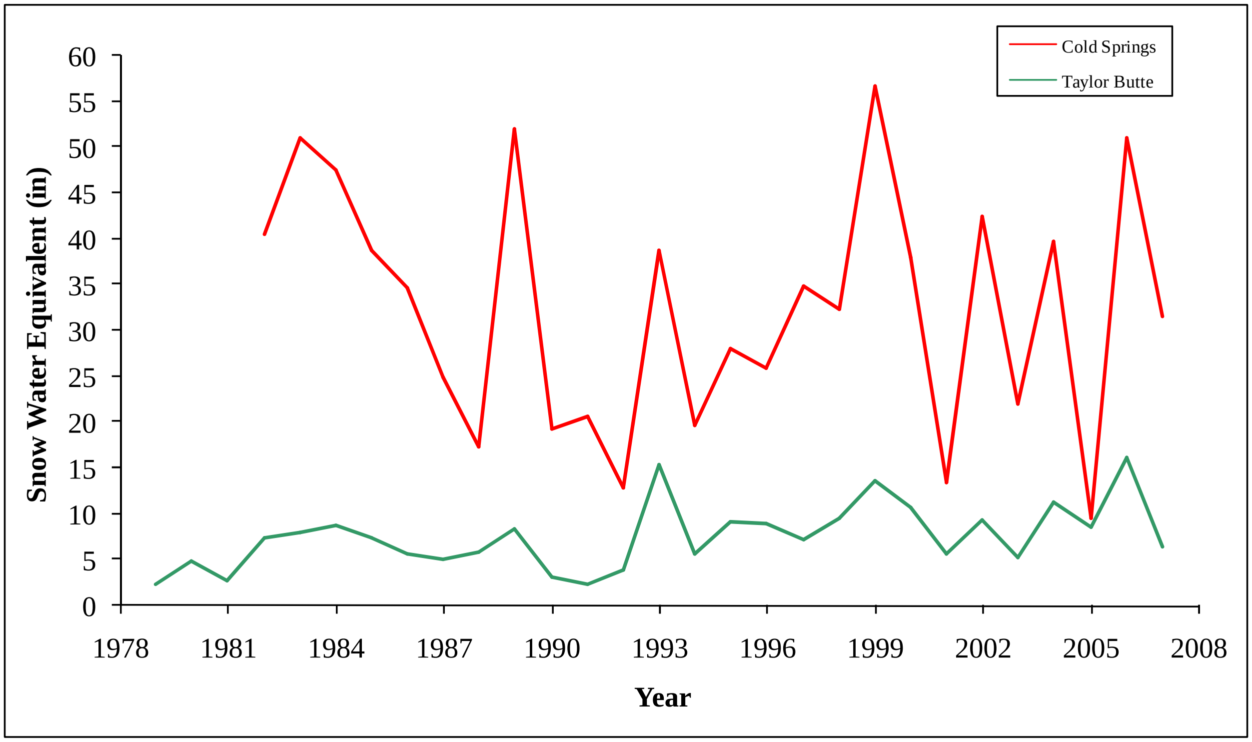


Figure 5-3 Maximum annual snow pack (snow water equivalent) at snow survey sites in the vicinity of the Lower Sprague-Lower Williamson subbasin
(Data Source: NRCS 2006)

Table 5-4 Snow survey sites in the vicinity of the Lower Sprague-Lower Williamson subbasin
(Data Source: NRCS 2006)

Site Name	Site ID	Elevation (ft)	County	Land Ownership	HUC	Latitude (degrees)	Longitude (degrees)	Installed in Water Year
Cold Springs Camp	22G24S	6,100	Klamath	Winema NF	18010203	42.53	-122.18	1982
Swan Lake Mtn	21G16S	6,800	Klamath	Private	18010204	42.40	-121.70	2006
Taylor Butte	21G03S	5,100	Klamath	Winema NF	18010201	42.70	-121.40	1979

Groundwater

Subsurface geology in the Sprague River valley is complex, and groundwater dynamics are not well understood. Studies have been completed by the U.S. Geological Survey to attempt to clarify groundwater relationships in the Sprague basin (Gannett et al. 2007). Information below was taken from this report. Some of the information for the material below was taken from a report prepared in 1974 (Leonard and Harris 1974). In the 1980s, the Oregon Water Resource Department conducted groundwater studies within the Whiskey Creek drainage. Although more recent work indicates that the geology and water-bearing characteristics may be more complex than previously described, it provides a useful introduction to a complex issue.

The source of most groundwater in the Klamath Basin is precipitation that falls within the basin and infiltrates into the ground, largely in the mountains. The porous pumice and fractured volcanic rocks in the mountains readily absorb precipitation and transmit it toward the lowland areas. Infiltration and recharge are greatest along the eastern slope of the Cascades and the northern end of the basin (Leonard and Harris 1974).

Part of the groundwater occurs in a relatively shallow zone under water-table or perched conditions, and part in a deeper zone, largely under confined conditions. Groundwater in the shallow zone generally moves only a short distance from its source before it is discharged through springs along the mountain slopes (Leonard and Harris 1974).

A large part of water that infiltrates into the ground seeps downward to deep zones and moves laterally toward and beneath the lowlands. Where favorable permeable zones for fracture are intersected by streams, some of this water is discharged into the stream by springs. The general movement of groundwater in the deeper zone is from north to south and from the uplands toward the valleys. At least some of the lowlands are areas of discharge, where groundwater is discharged by upward seepage from confined aquifers and through springs (Leonard and Harris 1974).

Inflow to the lowlands of the Sprague River valley is largely from the north and east, although some groundwater moves toward the valley from the southeast and south. There is also a downstream component of groundwater movement within the lowland area. Water levels in the main aquifer along the Sprague River are 100 to 200 feet higher than in neighboring valleys. This suggests that groundwater could move from the Sprague River valley to the Swan and Yonna valleys, but data from Leonard and Harris (1974) are not adequate to verify such movement. There is a some debate over this assumption, because there is not adequate data to support this theory (Bruce Topham, pers. comm. 2008).

Range and upland areas in the Upper Klamath Basin interior and eastern margins drain toward stream valleys and interior subbasins. Groundwater discharges to streams throughout the basin, and most streams have some component of groundwater (baseflow). Some streams, however, are predominantly groundwater-fed and have relatively constant flows throughout the year. Large amounts of groundwater discharge in the Wood River subbasin, the lower Williamson River area, and along the margin of the Cascade Range. Much of the inflow to Upper Klamath Lake can be attributed to groundwater discharge to streams and major spring complexes within a dozen or so miles from the lake. This large component of groundwater buffers the lake somewhat from climate cycles (Gannett et al. 2007).

There are also groundwater discharge areas in the eastern parts of the Upper Klamath Basin, for example in the upper Williamson and Sprague River subbasins and in the Lost River subbasin at Bonanza Springs. One such groundwater discharge creek is Spring Creek. This creek originates from a large spring in Collier State Memorial Park on the western side of Highway 97. This creek delivers clean, cold water to the lower Williamson River some distance above the confluence of the Sprague and Williamson rivers.

Throughout the Lower Sprague-Lower Williamson River subbasin, there are groundwater discharge areas. However, seepage is not uniform, but rather is concentrated in a few parts of the valley. Seeps and large springs are the principal sources of discharge (Leonard and Harris 1974).

Artesian wells were developed in a broad area from near Beatty to the town of Sprague River. Some wells are in use, some are no longer flowing, and some have been capped and are not currently being used. The current status of these artesian wells was unavailable. At least 35 flowing wells existed in this area in the 1970s (Leonard and Harris 1974).

The groundwater system in the Upper Klamath Basin responds to external stresses such as climate cycles, pumping, lake stage variations and canal operation. This response is manifested as fluctuations in hydraulic head (as represented by fluctuations in the water-table surface) and variations in groundwater discharge to springs. Basin wide, decadal-scale climate cycles are the largest factor controlling head and discharge fluctuations. Climate-driven water-table fluctuations of more than 12 feet have been observed near the Cascade Range, and decadal-scale fluctuations of 5 feet are common throughout the basin. Groundwater discharge to springs and streams varies basin-wide in response to decadal-scale climate cycles (Gannett et al. 2007).

Stream Flow

The hydrology of the Lower Sprague-Lower Williamson subbasin is complex. It includes large marshes, numerous small wetlands, springs and multiple patterns of groundwater discharge. Stream flow is supplied primarily by snowmelt and groundwater. Many small streams are seasonal, drying up in the summer. In other parts of the subbasin, perennial streams, such as Spring Creek, receive substantial groundwater inputs, maintaining cool water temperatures throughout the summer and fall.

Stream flow can be influenced by precipitation patterns and amounts, snowpack development and melting, pumping of groundwater to the surface, whether water infiltrates into the soil or runs off, vegetative cover, and water loss to the atmosphere through evapotranspiration (ET). ET includes water loss by evaporation from water bodies and the soil, and also loss from plants through transpiration. Plants exchange oxygen and carbon dioxide with the atmosphere through tiny pores called stomata. When stomata open to allow gas exchange, the plant also loses some water to the atmosphere through the process called transpiration.

In addition to climatic limitations on the availability of water, various human activities have exacerbated the limited water supply and time of availability. These activities have included ecological changes that have contributed to denser and more extensive forest ecosystems, reduction in the amount of wetland acreage, construction of water impoundments, widening of stream channels, construction of the Chiloquin Dam and increased water use. Changes in forest age, distribution and species composition from historic conditions have probably resulted in changes to the hydrologic regime, although the magnitude of such changes is unknown. Changes to riparian areas may also have affected the hydrology of the streams. The net effect of different riparian plant communities on stream flow, in comparison to irrigated plants such as pasture grasses and hay, is not well understood. A stream system that is in proper functioning condition (PFC) can store a large amount of water in the soil and the deep root systems of native plants in the floodplain and riparian zone. However, the rate of water loss by ET for some native plants is higher than irrigated plants. Consequently, it is difficult to state with certainty how changing the vegetation community will ultimately affect stream flow.

Two USGS stream flow gages collect stream discharge (flow) data in the Lower Sprague-Lower Williamson subbasin. They are listed in Table 5-5 and illustrated on Map 5-3. These two gages have adequate data, which has been recorded for more than 86 years (USGS 2005).

Table 5-5 Stream flow records from the Lower Sprague-Lower Williamson subbasin (Data Source: USGS 2005)

Gage Number	Gage Name	Period of Record
11501000	Sprague River near Chiloquin	03/1921 - 10/12/2007
11502500	Williamson River below Sprague River near Chiloquin	10/1/1917 - 10/9/2007

The annual cycle of discharge in streams in the Lower Sprague-Lower Williamson subbasin is offset from the annual precipitation cycle, because much of the precipitation falls as snow and accumulates until spring, when it melts. Peak discharge in subbasin streams usually occurs in the spring, well after the period of maximum precipitation. Maximum discharge can be influenced by rain-on-snow events that can occur at any time throughout the winter, depending on local climatic events. Monthly flows for streams in the Lower Sprague-Lower Williamson subbasin are illustrated in Figure 5-4. Peak flows in the Sprague River near Beatty typically occur in May, whereas peak flows in the lower Sprague River (near Chiloquin) occur in April. The lower Williamson River below the Sprague River confluence also exhibits peak flows during April. Minimum flow at both gages occurs in August and September. Flows in the Sprague River near Beatty, lower Sprague River, and Williamson River, typically begin increasing in December and gradually increase to the peak flow.

Minimum Flow

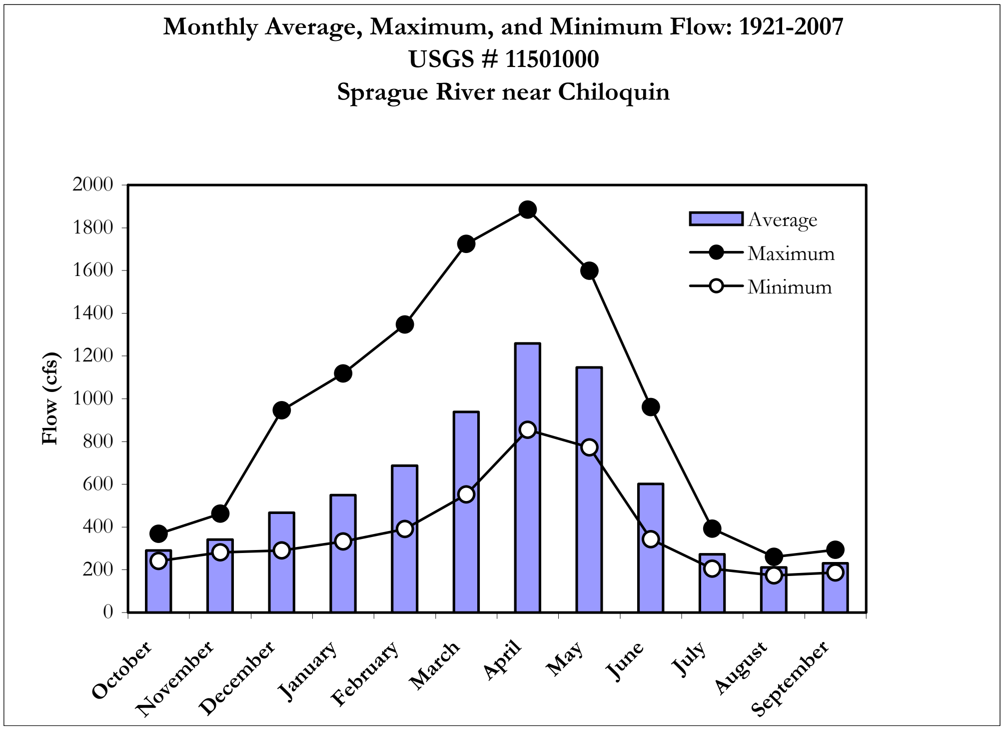
The dependence of flow on snowmelt combined with a lack of substantial snow in the late summer leads to the minimum flows exhibited from July through October. Only 15 to 17 percent of average annual flow occurs in the Sprague River near Beatty from July through October. Minimum daily average flow during July through October is about 58 percent of normal daily flow in the Sprague River near Beatty, The low-flow history in the Sprague River near Chiloquin and the Williamson River below the Sprague River confluence is summarized in Figure 5-5. The available data show several drought cycles, with lowest flows occurring around 1955, 1981, 1994 and 2002 (USGS 2005).

Peak Flow

Annual peak flows of streams within the Lower Sprague-Lower Williamson subbasin can occur during winter, spring or summer. Furthermore, peak flows can occur in response to rain, rain-on-snow or snowmelt events. An investigation of the hydrology of the region including the Lower Sprague-Lower Williamson subbasin (WPN 1999) identified that 57 percent of all annual peak flow values recorded at the 19 flow monitoring stations in the southern portion of the East Cascades ecoregion occurred in the spring months, while 25 percent occurred during winter. Peak flows are usually associated with a warm spell and rain-on-snow events. In combination, the spring snowmelt and spring rain or rain-on-snow events accounted for slightly more peak flows than did winter rain and rain-on-snow processes. Summer rainstorms were also identified as a regular producer of annual peak flows in some streams.

Peak flows are associated with spring snowmelt and summer rainstorms for all ecoregions, although the Pumice Plateau Forest ecoregion also experiences rain-on-snow events in the spring and sometimes in the summer. Stream flows tend to be slightly higher in the winter and spring than at other times of the year for the Klamath/Goose Lake Warm Wet Basins, Fremont Pine/Fir Forest and Klamath Juniper/Ponderosa Pine Woodland ecoregions. The Pumice Plateau Forest ecoregion experiences high stream flows in both late spring and in the fall and winter for some streams. The other three ecoregions exhibit the highest stream flows in spring, with a small peak again from late summer rains (Table 5-2).

Peak flow patterns for the two stations with the most comprehensive flow data are illustrated in Figure 5-6. The two largest flow events recorded for the Sprague River, Fall 1964 and Winter 1997, were the result of rain-on-snow events. Eyewitness accounts of the flood in 1997, including one by Craig Bienz, describe the flood as stretching "from valley wall to valley wall." Cliff Rabe comments on the flood of 1997, "I have never seen the river [Sprague River] so high. The river even flooded the stack yard [for hay bales]."



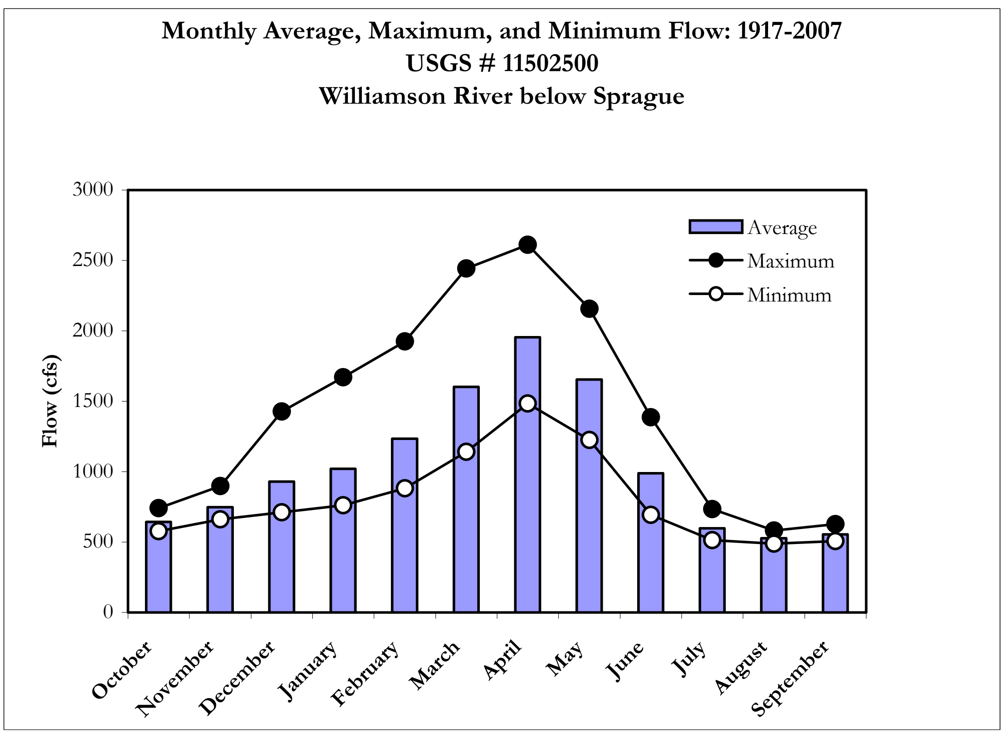
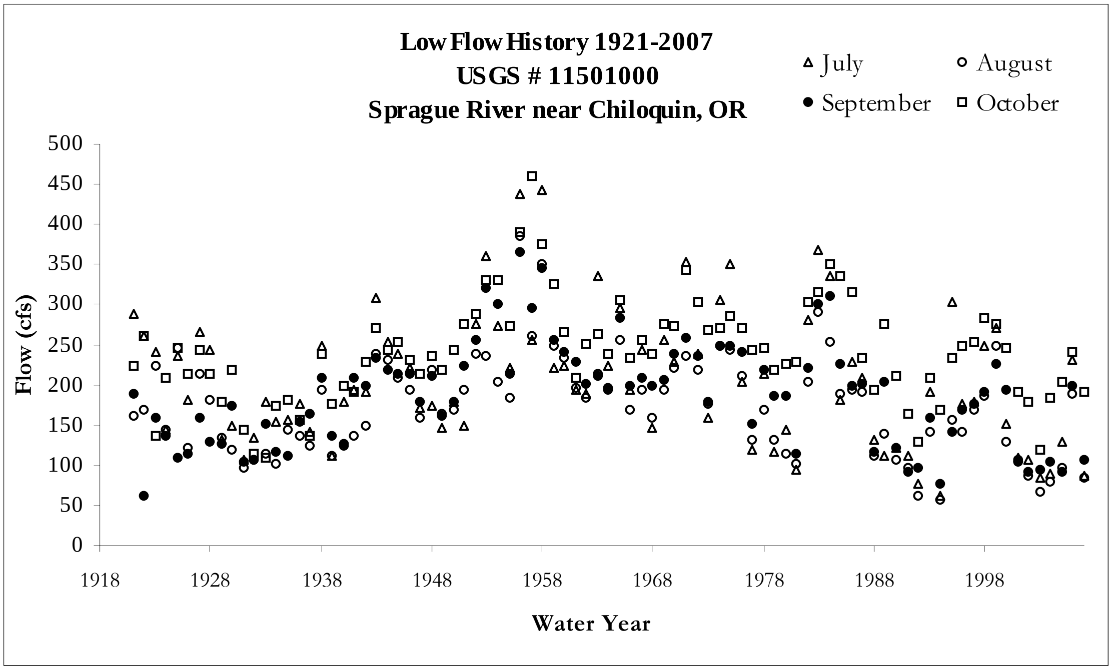


Figure 5-4 Monthly stream flow throughout the period of record in the Sprague River near Chiloquin and the Williamson River below Sprague confluence (Data Source: USGS 2005)



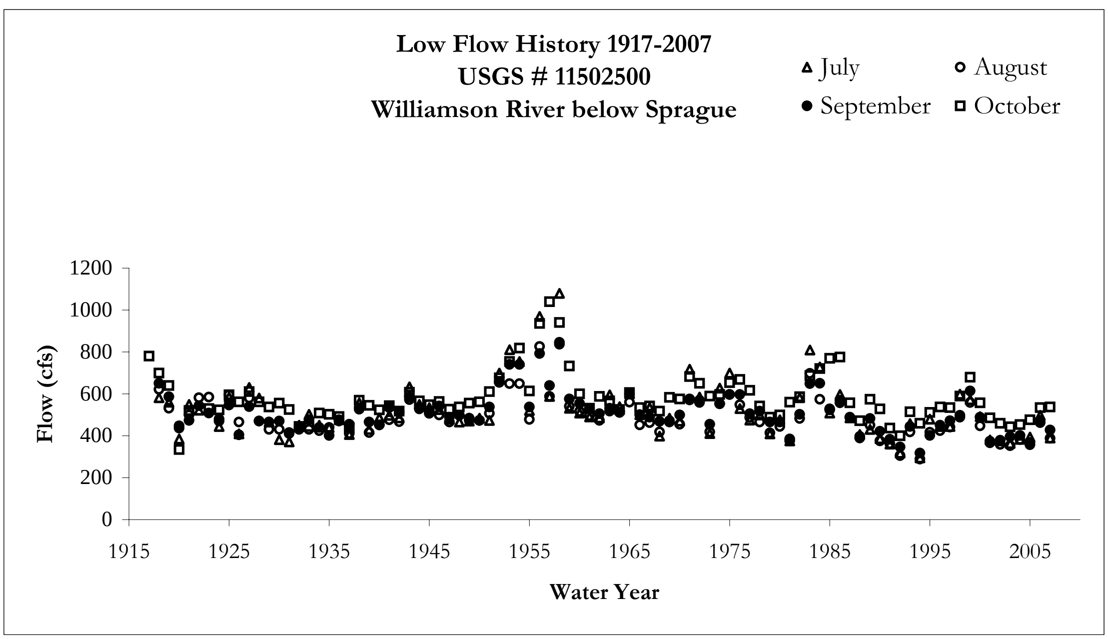
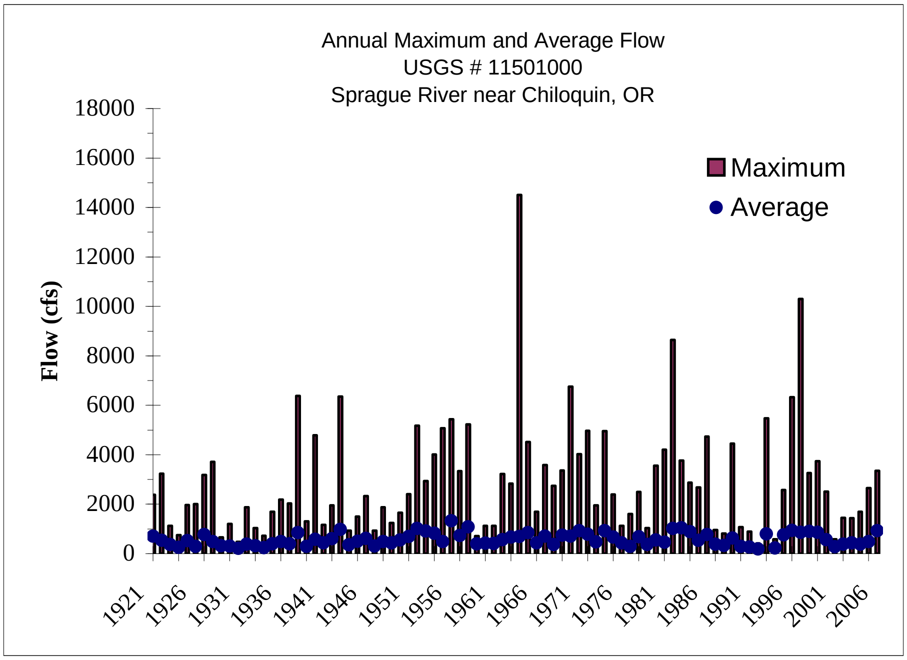


Figure 5-5 Low-flow history for the period of record for the Sprague River near Chiloquin and Williamson River below Sprague confluence (Data Source: USGS 2005)



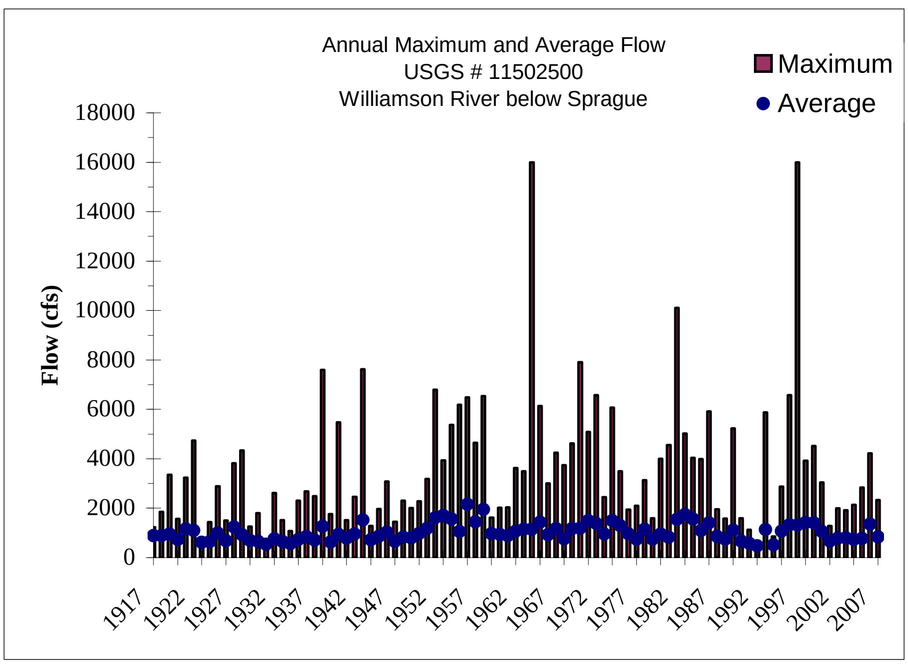


Figure 5-6 Annual peak flow measured in the Sprague River near Chiloquin and the Williamson River below Sprague confluence
Data Source: USGS 2005)

WATER USE

Irrigated agriculture is an integral part of the economy of the Upper Klamath Basin. Although estimates vary somewhat, roughly 500,000 acres are irrigated in the Upper Klamath Basin, about 190,000 acres of which are part of the U.S. Bureau of Reclamation's Klamath Project. Most of this land is irrigated with surface water. Groundwater has been used for many decades to irrigate areas where surface water is not available, for example, outside of irrigation districts and stream valleys. Groundwater has also been used as a supplemental source of water in areas where surface water supplies are limited and during droughts. Groundwater use for irrigation has increased in recent years due to drought and shifts in surface water allocation from irrigation to in-stream uses.

This section presents information on water use within the Upper Sprague River subbasin. Under Oregon law, most available water is publicly owned (Bastasch 1998). A water right entitles a person or organization to withdraw publicly owned water for a specific type of use, for example, domestic use, livestock watering, or irrigation. The Oregon Water Resources Department (OWRD) issues water rights to both private and public users through a permitting process (Bastasch 1998). In Oregon, water rights are distributed according to the "principle of prior appropriation," which means that older water rights have priority over newer ones. If water becomes scarce during dry years, the holders of the most recently issued water rights will be the first who are required to cease withdrawing water to ensure that an adequate supply is available for the holders of more senior water rights (OWRD 2001).

Regional stakeholders are currently involved in a contested water rights adjudication. In the attempt to support their respective claims, various stakeholders have produced data and information on hydrology and water use. Because each of these entities is a claimant in the ongoing adjudication, the data they have produced are frequently disputed by entities with competing claims.

Water is withdrawn for a broad array of beneficial uses. Water is used to grow crops or forage for livestock. Towns and cities withdraw water, as do rural residents, for domestic use. Water is also required by the fish and other organisms that live in the streams. Frequently, the need for water for a multitude of beneficial uses results in conflicting opinions on how priorities should be set.

Consumptive Water Use

In this section, information regarding the maximum diversion rate permitted for consumptive use is summarized from available information on OWRD's website (OWRD 2006). This maximum diversion rate represents the maximum potential diversion from all surface water right permits, not necessarily the amount that is actually used. The actual amount diverted for use varies seasonally and from year to year, and is usually less than the maximum allowed amount (OWRD 2006). Consumptive water use does not include groundwater or storage (i.e., wells or reservoirs). In-stream water rights are also excluded from these analyses because they do not entail removing water from the hydrologic system, but they are discussed in the subsequent section.

Permitted flow rates for water withdrawal do not provide an accurate indication of the amount being withdrawn, which varies seasonally, because not all permit-holders use all of their allocated water. Also, most of the withdrawn water returns to the stream, and may be withdrawn again by another downstream user (Cooper 2002).

Oregon Water Resources Department (OWRD) categorizes consumptive uses into three categories: irrigation, municipal, and all other uses. The categories are based on water right and in some cases actual diversion is less than maximum allowable diversion. (Cooper 2002)

The following methods are widely used to estimate irrigation consumptive use in a watershed (Cooper 2002):

1. Multiply the number of acres permitted to be irrigated by all water rights by the permitted duty;
2. Summing the permitted rates of diversion for all water rights;
3. Summing the actual diversions; and
4. Taking a census of the actual number of acres irrigated and the type of crops grown, then finding the consumptive use based on crop water requirements.

OWRD describes the methods #1 through #3 (above) as over-estimating consumptive use. Using the method #4 (described above), OWRD estimates that, in Oregon, over 80 percent of water use is for irrigation. In 1990, 91 percent of diversions for irrigation were from surface water, and 43 percent of the water diverted was used consumptively by the crops (Cooper 2002). This method (#4) does not account for the remaining 48 percent diverted, but not consumed, and this amount would presumably vary by irrigator.

Groundwater pumping may augment stream flows. Alternatively, groundwater pumping can reduce natural spring and groundwater input to streams. The effects of the timing and location of withdrawal are additional considerations.

The following water uses may not require a water right: natural springs, stock watering, salmon propagation, fire control, forest management, and rainwater collection (OWRD 2001). Groundwater uses that are exempt include stock watering, lawn and garden watering (less than one-half acre) and domestic water uses of no more than 15,000 gallons per day.

OWRD also approves in-stream water rights, which are rights that keep water in the stream for the benefit of fish, minimizing the effects of pollution or maintaining recreational uses (OWRD 2001). In-stream water rights designate monthly flows and are regulated in the same manner as other water rights. They do not guarantee that a certain quantity of water will be present in the stream, because they cannot affect a use of water with a senior priority date (OWRD 2001).

If water has been continuously used since before the establishment of water laws in Oregon in 1909, the property owner may have a "vested" water right. These uncertified rights, or "claims," can be found valid in a judicial (court) process known as adjudication. The process of adjudicating water rights is currently under way in the Sprague River basin on lands that were formerly part of the Klamath Indian Reservation. The area outside of the former reservation is not included in the ongoing adjudication process, because that area has already been adjudicated. Most of the land under adjudication lies outside the assessment area. Once the adjudication process is complete, OWRD will issue water right certificates for each decreed right (OWRD 2001).

Information on water rights that have been adjudicated or permitted is available from the OWRD. OWRD provides online access to databases including the Water Rights Information System (WRIS) and the Water Availability Reporting System (WARS). Using the WRIS database, it is possible to download a list of water rights or claims for drainage basins within Oregon. However, this list may

change in the Lower Sprague-Lower Williamson subbasin as a result of the ongoing adjudication process.
A consumptive use is defined as any water use that causes a net reduction in stream flow (Cooper 2002). Oregon Revised Statute (ORS) 536.340 authorizes the Water Resources Commission to classify water for beneficial use. A classification indicates the uses for which new water permits can be issued, including domestic, municipal, irrigation, power development, industrial, mining, road construction, manufacturing, recreation, wildlife, fish and pollution abatement. These uses are usually associated with a loss from evaporation or transpiration, or the water may be withdrawn from the system (Cooper 2002).

Water uses are generally not considered to be 100 percent consumptive. Consumptive use is estimated by multiplying a consumptive use coefficient (e.g., for domestic use, the coefficient is 0.20) by the maximum diversion rate allowed for the water right. The OWRD assumes that all of the nonconsumed part of a diversion returns to the stream from which it was diverted (Cooper 2002). The exception is when diversions are from one watershed to another, in which case the use is considered to be 100 percent consumptive (i.e., the consumptive use equals the diversion rate (Cooper 2002)).

Locations where water is withdrawn for consumptive use are referred to as points of diversion. Points of diversion are broadly distributed throughout the Lower Sprague-Lower Williamson subbasin, although the highest density is in the valley reaches and Williamson River Delta portions of the study area (Table 5-6, Map 5-3). According to the OWRD database, there are 303 points of diversion in the Lower Sprague-Lower Williamson subbasin. The Sprague River watershed has the most points of diversion, at 138. The West Sprague River watershed has 75 points of diversion, and the Williamson River watershed 72. The North Sprague River watershed has the least points of diversion, at 17. It should be noted that more than one water right may be associated with a single point of diversion, so the number of points of diversion does not correspond to the total number of water rights or water right claims in the subbasin.

Table 5-6 Number of points of diversion by watershed in the Lower Sprague-Lower Williamson subbasin
(Data Source: OWRD 2007)

Watershed Name	Number of Water Rights	Number of Points of Diversion
North Sprague River	19	17
Sprague River	163	138
West Sprague River	82	75
Williamson River	83	72
Total	**347**	**302**

In-stream Rights

Water that is withdrawn from a stream has the potential to affect in-stream habitat for aquatic organisms by changing flow or dewatering the stream. Some of the water that is removed from the channel for irrigation is permanently lost from that stream as a result of plant transpiration and evaporation. Some is returned to the stream channel. The permanent removal of water from the stream channel lowers the in-stream flows. Water can also be added to the stream channel via pumping of groundwater. Possible effects of changes to water availability include increased water temperatures, the creation of fish passage barriers, altered sediment transport capacity, and altered habitat quality for aquatic organisms. This Assessment does not attempt to quantify either the removal of water from the system through consumptive use or any increase in water that may occur from groundwater pumping. The assessment is only summarizing available data.

In-stream water rights were established by Oregon Department of Fish and Wildlife (ODFW) throughout much of the subbasin in 1990 to prevent additional withdrawals, in order to retain water in the stream for fish and other aquatic species. Because these water rights are junior to the majority of the consumptive water rights, there is no guarantee that in-stream rights will be met. Flow of the Sprague River near Beatty falls below the designated in-stream water right for resident fish habitat only infrequently, most commonly in August (a total of 36 days in August over the period of record for the stream flow data).

All of the watersheds in the Lower Sprague-Lower Williamson subbasin have in-stream water rights created by ODFW for anadromous and resident fish habitat, most of which were established on October 26, 1990 (OWRD 2006). The in-stream rights were established by ODFW primarily to ensure that later claims can be prevented from removing water that may adversely affect aquatic species. Additionally, although the purpose of the in-stream water rights is to protect aquatic habitat by retaining water in the stream, the flow rates of the in-stream rights are not exact, site-specific determinations of habitat requirements.

DATA, METHODS AND LIMITATIONS

The purpose of the Watershed Assessment is to present a broad overview of conditions at the scale of the watershed and subwatershed. The information in this chapter was gathered from already existing data acquired from public agencies. The information used in this Assessment should be reliable for the types of analyses and at the spatial scales presented. However, the completeness and accuracy of the data are determined by each individual data source. Source citations are included with each display item. Caution should be used when planning on-the-ground projects. Use of the data at spatial scales significantly different from the source information may result in errors or inaccuracies. In other words, the data accuracy is acceptable for the watershed scale, but not refined enough for the farm or ranch planning scale.

REFERENCES

Barrett, H. 2007. Western Juniper Management: A Field Guide. Oregon Watershed Enhancement Board. Salem, OR.

Bastasch, R. 1998. Waters of Oregon: A Source Book on Oregon's Water and Water Management. Oregon State University Press. Corvallis, OR.

Cooper, R.M. 2002. Determining Surface Water Availability in Oregon. State of Oregon Water Resources Department, Open File Report SW 02-002. Salem, OR.

Daly, C., R.P. Neilson, and D.L. Phillips. 1994. A statistical-topographic model for mapping climatological precipitation over mountainous terrain. Journal of Applied Meteorology 33:140-158.

Gannett, M.W., K.E. Lite, Jr., J.L. La Marche, B.J. Fisher, and D.J. Polette. 2007. Ground-water hydrology of the upper Klamath Basin, Oregon and California: U.S. Geological Survey Scientific Investigations Report 2007-5050.

INR (Institute for Natural Resources). 2004. Scientific Consensus Statement on the Likely Impacts of Climate Change on the Pacific Northwest. From the Conference on the Impacts of Climate Change on the Pacific Northwest. Corvallis, OR.

IPCC (International Panel on Climate Change. 2001. Climate Change 2001. Synthesis Report. Watson, R.T. and the Core Writing Team (Editors). PICC, Geneva, Switzerland.

Leonard, A.R. and A.B. Harris. 1974. Ground Water in Selected Areas in the Klamath Basin, Oregon: Oregon State Engineer Ground Water Report No. 21.

NRCS (Natural Resources Conservation Service). 2006. National Water and Climate Center. SNOTEL. Online database. http://www.wcc.nrcs.usda.gov/snow/ (accessed February 2006).

OCS (Oregon Climate Service). 2007. Zone 3 – Climate Data Archives. Online database. http://www.ocs.oregonstate.edu/page_links/climate_data_zones/allzone3.html (accessed December 2007).

OCS (Oregon Climate Service). 2006. PRISM . Online database. http://www.ocs.oregonstate.edu/page_links/climate_data_zones/allzone3.html (accessed February 2006).

ONHP (Oregon Natural Heritage Program). 1995. Ecoregions. GIS data file. http://gis.oregon.gov/DAS/EISPD/GEO/alphalist.shtml (accessed June 2006).

OWRD (Oregon Water Resources Department). 2007. Points of Diversion. Online database. http://www.wrd.state.or.us/OWRD/MAPS/ index.shtml#Water_Right_Mapping_Status (accessed October 2007).

OWRD (Oregon Water Resources Department). 2006. Water Availability Report System (WARS). Online database. Telnet://wars.wrd. state.or.us (accessed March 2006).

OWRD (Oregon Water Resources Department). 2001. Water Rights in Oregon: An Introduction to Oregon's Water Laws and Water Rights System. Salem, OR.

Topham, Bruce. 2008. Personal communication.

USGS (U.S. Geological Survey). 2005. National Water Information System. Online database. http://waterdata.usgs.gov/or/nwis/rt. (accessed September 2006).

WPN (Watershed Professionals Network). 1999. Oregon Watershed Assessment Manual. Prepared for the Governor's Watershed Enhancement Board. Salem, OR.

WRCC (Western Regional Climate Center). 2006. Oregon Climate Summaries. Website. http://www.wrcc.dri.edu/summary/climsmor.html (accessed September 2006 and October 2007).