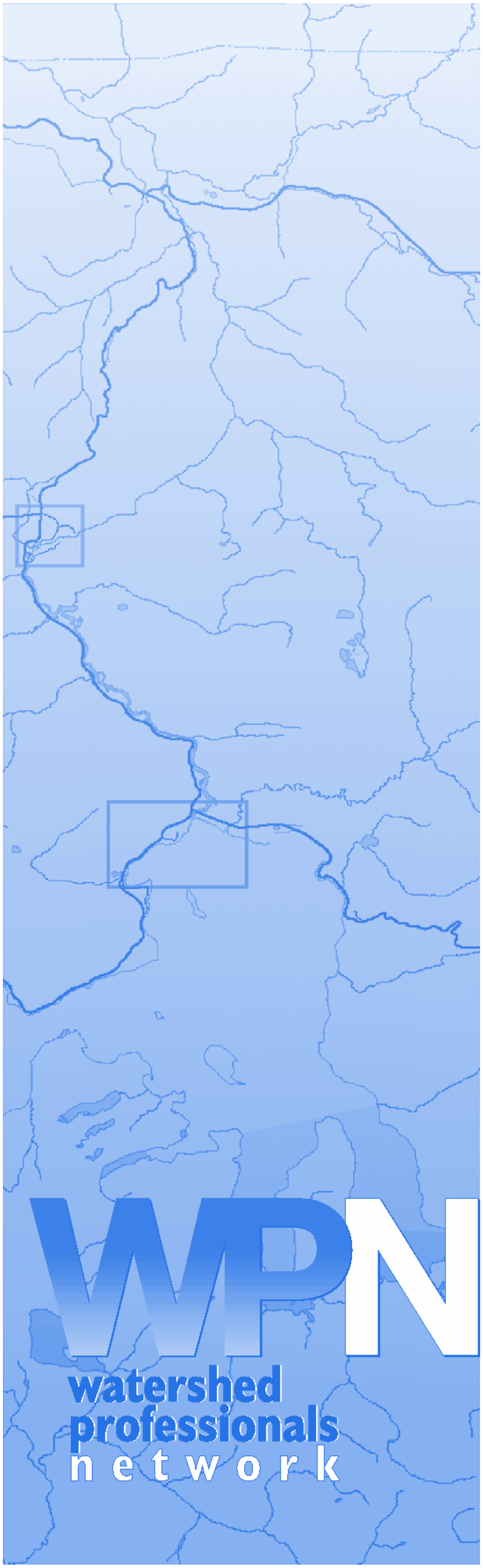

WRIA 30

PHASE II WATERSHED ASSESSMENT

Prepared for:
Klickitat County Planning Unit

Prepared by:
Watershed Professionals Network
And
Aspect Consulting

January 2005

WRIA 30

PHASE II WATERSHED ASSESSMENT

January 10, 2005

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WRIA 30

PHASE II WATERSHED ASSESSMENT

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WRIA 30 Phase II Watershed Assessment

1.0 INTRODUCTION

1.1 PURPOSE

In 1998 Chapter 90.82 of the Revised Code of Washington was amended with the passage of ESHB 2514. This law is also known as the Watershed Planning Act. The legislature found that *"local development of watershed plans for managing water resources and for protecting existing water rights is in the vital interest of both state and local interests. Local development of these plans serves vital local interests by placing it in the hands of people who have the greatest knowledge of both the resources and the aspirations of those who live and work in the watershed and who have the greatest stake in the proper, long term management of the resources. The development of such plans serves the state's vital interests by ensuring that the state's water resources are used wisely, by protecting existing water rights, by protecting instream flows for fish, and by providing for the economic well-being of the state's citizenry and communities"* (RCW 90.82.010) The Watershed Planning Act describes a planning process that is completed in four phases. Phase I is organizational, Phase II is the assessment of conditions in the watershed, Phase III is the development of a watershed plan, and Phase IV is the implementation of the plan.

Watershed planning under the Watershed Planning Act is initiated with the concurrence of the counties with territory in the Watershed Resource Inventory Area (WRIA) being planned for and the largest city and largest water purveyor in the WRIA. These entities, and any Indian Tribe that accepts the invitation, become the "initiating governments" that, among other organizational responsibilities, determine the scope of the planning effort. The scope of planning must address water quantity and may, as determined by the initiating governments, address the optional elements of water quality, instream flows, and/or habitat. The scope of the planning effort for WRIA 30 includes water quantity, water quality, and habitat, but not instream flows.

The process for completing the first three phases of the assessment is outlined in the Department of Ecology's draft *Guide to Watershed Planning and Management*. The guide identifies recommended elements for a Phase II assessment. These are summarized below. Note that the *Guide* included several items under habitat that actually addressed water quality. These items have been moved under the water quality heading.

Water Quantity

- Estimate of surface and groundwater present in the management area.

- Estimate of the water in the management area represented by claims in water rights, claims registry, water use permits, certificated rights, existing minimum instream flow rules, federally reserved rights, and any other rights to water.
- Estimate of the surface and groundwater actually being used in the management area.
- Estimate of the water needed in the future for use in the management area.
- Identification of the location of areas where aquifers are known to recharge surface bodies of water and areas known to provide for the recharge of aquifers from the surface.
- Estimate of the surface and groundwater available for further appropriation, taking into account the minimum instream flows adopted by rule or to be adopted by rule under this chapter for streams in the management area including the data necessary to evaluate necessary flows for fish.

Water Quality

- An examination based on existing studies conducted by federal, State, and local agencies of the degree to which *legally* established water quality standards are being met in the management area.
- An examination based on existing studies conducted by federal, State, and local agencies of the causes of water quality violations in the management area, including an examination of information regarding pollutants, point and nonpoint sources of pollution, and pollution-carrying capacity of water bodies in the management area.
- The analysis shall take into account seasonal stream flow or level variations, natural events, and pollution from natural sources that occur independent of human activities.
- An examination of legally established characteristic uses of each of the nonmarine bodies of water in the management area.
- An examination of the impacts to beneficial or characteristic uses, caused by changes in watershed hydrology.
- An examination of any total maximum daily load established for nonmarine bodies of water in the management area, unless a total maximum daily load process has begun in the management area as of the date the watershed planning process is initiated under section 2 of the Watershed Management Act.
- An examination of existing data related to the impact of fresh water on marine water quality.

Habitat

- The Watershed Planning Act specifies that planning is to be integrated with strategies developed under other processes to respond to potential and actual listings of salmon and other fish species under the Endangered Species Act. The

Salmon Recovery Act requires analysis of "limiting factors" in developing a habitat project list.

Phase II assessments are completed in two steps: a Level I Assessment and Level II studies. The Level I Assessment is completed to document the available information regarding water availability, water rights, water use, water quality, and fish habitat. The Level I Assessment also documents data gaps and makes recommendations for short term data collection as needed to support development of the watershed management plan. The methods used in the Level I assessment generally followed the guidelines of the Washington Department of Ecology's (Ecology's) draft *Guide to Watershed Planning and Management* as amended. The Level II studies are completed to address some of the data gaps identified in the Level I Assessment. In some cases, additional study or monitoring may be required to adequately address high priority unknowns that are identified during the Phase II assessment. The draft *Guide to Watershed Planning and Management* recognizes that these situations will exist and provides for "Level III" studies and monitoring that can be incorporated into the management plan and implementation plans.

The Level II studies conducted in WRIA 30 included an assessment of water storage options within the WRIA (completed in two phases), assessment of nitrate levels in groundwater in the Swale and Little Klickitat subbasins, and an assessment of water temperature in the Swale subbasin. Information gathered in the Level I Assessment and Level II studies will be used during the development of the WRIA 30 watershed plan (Phase III).

1.2 STUDY AREA

Water Resources Inventory Area (WRIA) 30 is located in Klickitat and Yakima Counties, Washington. The City of Goldendale and the communities of Lyle, Dallesport, Murdock, Klickitat, Centerville, Wishram, Mary Hill, and Glenwood are located within WRIA 30. The Columbia River lies along the southern edge of the watershed. For the purpose of this assessment, WRIA 30 was divided into six subbasins: Upper Klickitat, Middle Klickitat, Little Klickitat, Swale, Lower Klickitat, and Columbia Tributaries (Map 1). Most of the Upper Klickitat Subbasin and the eastern half of the Middle Klickitat Subbasin are dominated by Yakama Indian Reservation, which will not be included in the planning efforts.

1.3 DOCUMENT ORGANIZATION

The various parts of the Level I and Level II Assessments have been titled and laid out as follows:

- **Assessment Report** (this document) serves as the primary text of the Phase II report summarizing information contained in the Level I and Level II assessments,

- **Appendix A**, *WRIA 30 Level I Assessment*, contains the results of the Level I Assessment,
- **Appendix B**, *WRIA 30 Multipurpose Water Storage Screening Assessment Report*, contains the results of the first phase of the water storage assessment project (Level II),
- **Appendix C**, Addendum to *WRIA 30 Multipurpose Water Storage Screening Assessment Repor*t, contains the results of the second phase of the water storage assessment project (Level II),
- **Appendix D**, *WRIA 30 Phase II Watershed Assessment Nitrate Concentration and Distribution Study*, contains the results of the investigations into nitrate concentrations in ground water (Level II), and
- **Appendix E**, *WRIA 30 Swale Creek Water Temperature Study*, contains the results of the assessment of potential shade and temperature in Swale Creek (Level II).

The appendices were bound separately from this document to facilitate distribution. The reader is encouraged to refer to the pertinent appendices for additional information.

2.0 ENVIRONMENTAL SETTING

For the purposes of the Level I watershed assessment, WRIA 30 was subdivided into six subbasins (Figure 1). These include the Upper Klickitat, the Middle Klickitat, the Lower Klickitat, the Little Klickitat, Swale, and Columbia Tributaries Subbasins. Most of the subbasins incorporate one or more major tributaries as well as some of the smaller side tributaries that drain to the Klickitat River, however, the subbasin designated as "Columbia Tributaries" encompasses several very small tributaries, all of which drain directly to the Columbia River. Most of the Upper Subbasin and the eastern half of the Middle Klickitat Subbasin are dominated by Yakama Indian Reservation, which were nominally addressed in the assessment.

2.1 GEOLOGY AND TOPOGRAPHY

The topography of WRIA 30 varies in response to the underlying geology of the area (Appendix A, Chapter 2). The geology is dominated by relatively recent basalts and other volcanic rocks and contains many areas of high topographic relief, particularly in the vicinity of Mt. Adams. WRIA 30 has a generalized geologic history including: (1) widespread extrusion of numerous Miocene-age lava flows (Columbia River Basalt Group; CRB) from vents east of the watershed with a combined thickness ranging from zero to several thousand feet; (2) uplift of the Cascade Range immediately to the west, with resulting upwarp and erosion of the lava flows; (3) localized extrusion of lavas and ash from Mount Adams and several smaller volcanic cones; and (4) glaciation on the higher peaks, resulting in erosion of these peaks and deposition in down slope areas.

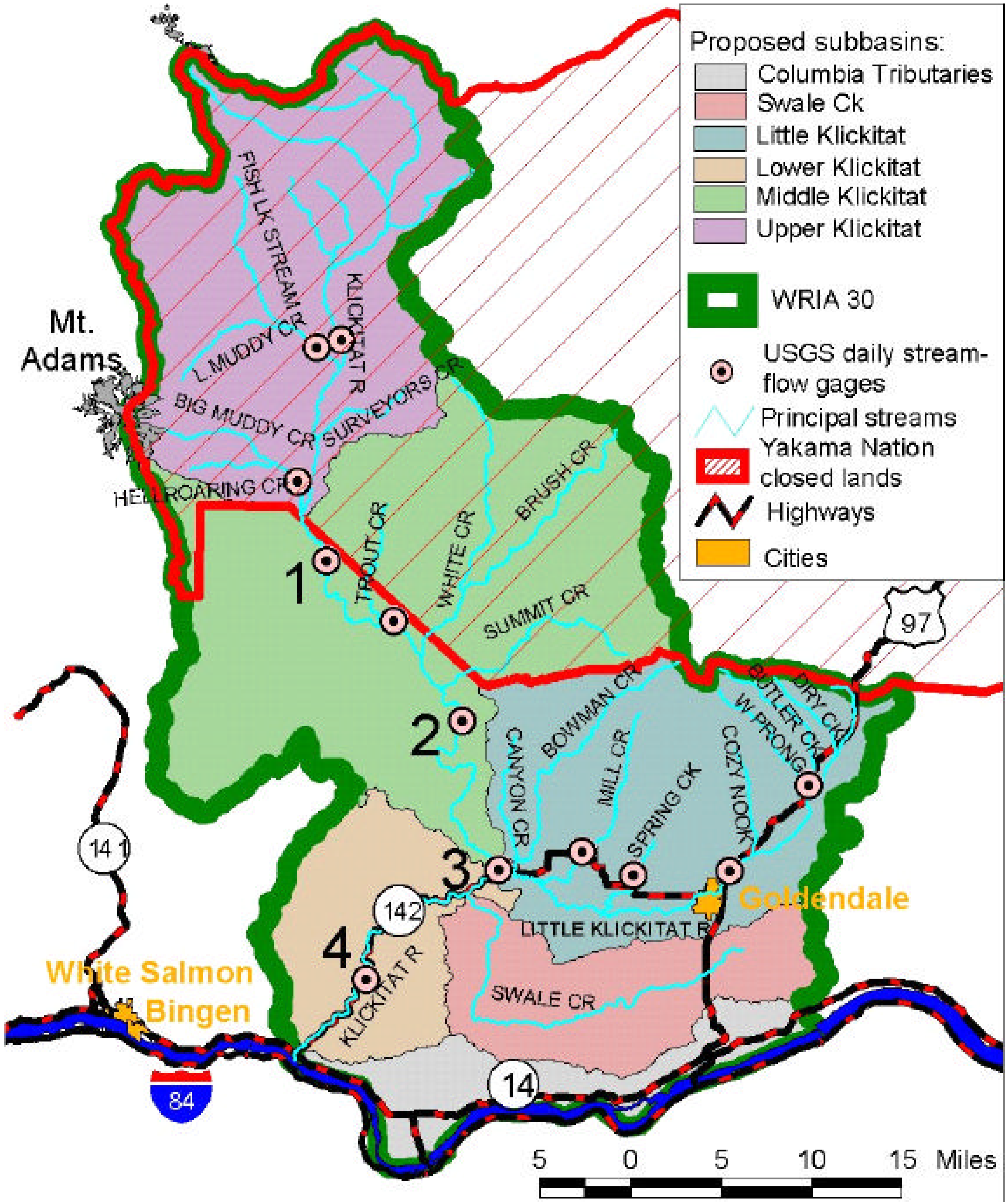

Figure 1. Map of WRIA 30 depicting major subbasins in the watershed. Adapted from Watershed Professionals Network, 2004 (Appendix A, Chapter 1).

The extensive erosion resistant basalt flows which dominate the basin have formed deep (700 to 1500 feet) steep-walled canyons. These canyons constrain floodplain development along most of the mainstem Klickitat. Local variations in erosion resistance of the underlying geology have resulted in the formation of cascades and waterfalls along the mainstem and in many tributaries. This geomorphology creates a pattern where most of the Klickitat mainstem is a canyon with steep walls and a narrow valley floor. There are several waterfalls in these reaches which are among the main factors limiting anadromous fish (e.g., salmon and steelhead) distribution in the watershed. The stream reaches in the plateau areas are lower gradient and are able to develop meander patterns. These areas tend to have more agricultural, urban, and recreational land use, which can affect water and fish habitat quality.

From the surface down (youngest to oldest), the geologic units of primary significance with respect to WRIA 30 groundwater are:

- Alluvium
- Quaternary Volcanics (including Simcoe Volcanics)
- Wanapum Basalt
- Grande Ronde Basalt

Groundwater within WRIA 30 occurs both within the basalt bedrock units and the surficial alluvium (Appendix A, Chapter 5). Groundwater in the basalts occurs primarily at the tops of the individual flows ("flow top") that became vesicular (porous) as gas bubbles escaped the lava flows during cooling, and/or at the flow bottoms where molten lava encountered water ("pillow"). Flow tops and pillows are usually porous and permeable, and therefore transmit water more readily than the intervening massive portion of the basalt flow "interior". A flow top is normally present for each flow, while pillows range from relatively thick units to completely absent. Collectively, the flow tops and bottoms are referred to as interflow zones. In some locations, the interflows may be completely unproductive in terms of groundwater flow.

The continuity and distribution of water-bearing zones within the basalt bedrock are affected by the geologic structures. Folds and faults can disrupt the continuity of the permeable interflow zones. For example, where the Warwick Fault crosses the southwestern edge of the Swale Creek valley, it appears to act as a local hydraulic barrier impounding groundwater on the up gradient (east and northeast) side of the fault (toward Centerville). Faults also can provide conduits for vertical groundwater flow between water-bearing zones.

Median subbasin elevations generally decrease moving downstream through the basin, however, slopes are steeper both in the Upper and Lower Klickitat subbasins. The ground with lower relief is largely located in the Middle Klickitat, Little Klickitat, and Swale Creek subbasins.

In many areas of the watershed, the volcanic bedrock is overlain by unconsolidated sedimentary deposits comprised of gravels, sands, and silts of glacial or fluvial origin (collectively referred to as alluvium). Where the surficial alluvium is extensive, such as in the Swale Creek valley south of Goldendale and in the Camas Prairie area near Glenwood, it can provide a groundwater source for domestic supplies.

2.2 PRECIPITATION

Mean annual precipitation within WRIA 30 generally increases with elevation and from east to west (Appendix A, Chapter 2). Mean annual precipitation is as little as 9 inches per year in the eastern end of the Columbia Tributaries subbasin and as much as 105 inches per year on Mount Adams in the Upper Klickitat subbasin (Figure 2).

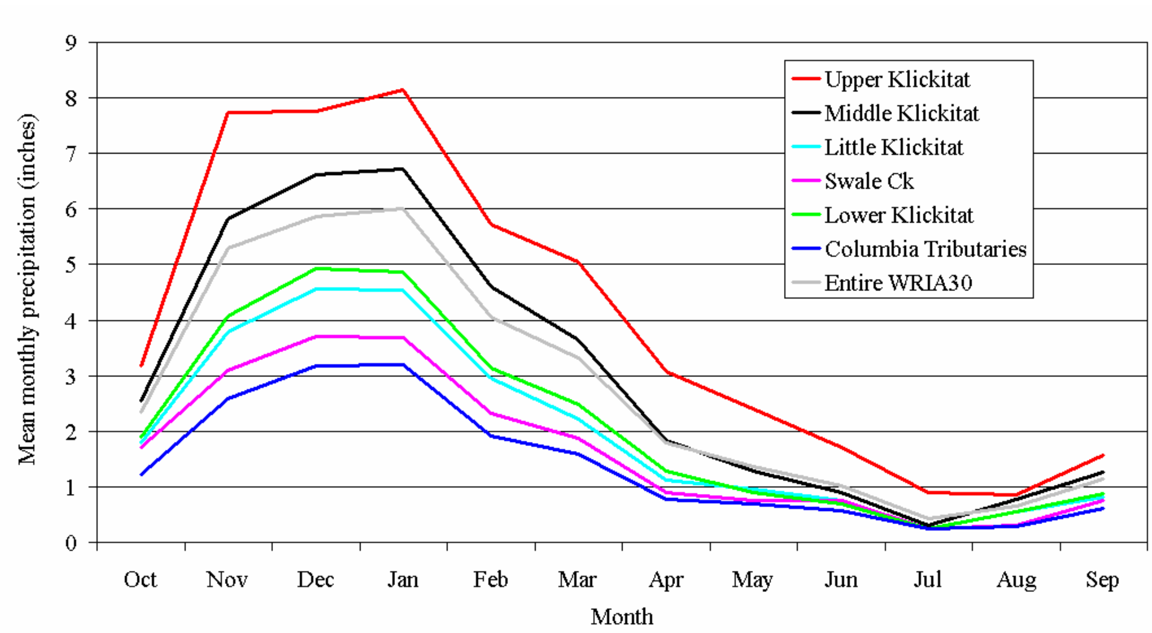

Figure 2. Mean monthly precipitation distribution.

In average years, a shallow snow pack is typically present on the first day of January in the majority of the Upper, Middle, and Little Klickitat subbasins and in approximately half of the Lower and Swale Creek subbasins. Snow is largely absent in the Columbia Tributaries subbasin on the first day of January. Snow pack typically increases in depth throughout the winter and spring in the Upper Klickitat subbasin and in the higher elevation areas of the Middle and Little Klickitat subbasins. Snow pack is typically at its maximum by the first day of April.

2.3 LAND USE

The primary land use in WRIA 30 is forestry (Appendix A, Chapter 2; Table 1). Shrublands are the second most common vegetation type in the watershed. Grazing is common in both forested and shrubland areas. Cropland is most common in the Little

Klickitat and Swale Creek subbasins. Developed areas (commercial and residential) cover only a small percentage of the watershed.

The Klickitat Wildlife Area (owned and managed by the Washington Department of Fish and Wildlife) covers roughly 14,000 acres in the Middle Klickitat subbasin. The area includes much of the middle mainstem of the Klickitat River and the adjacent lands. Conboy Lake National Wildlife Refuge is located north of the Glenwood area in the Middle Klickitat subbasin. This refuge is approximately 5,800 acres in size and is managed by the US Fish and Wildlife Service. The lower ten miles of the Klickitat River are designated as a recreational river under the Wild and Scenic Rivers Act and portions of the Lower Klickitat Subbasin (near the Columbia River) and the majority of the Columbia River Tributaries Subbasins lie within the Columbia River Gorge National Scenic Area.

Table 1. Vegetation/land use in WRIA 30.

	Upper Klickitat	Middle Klickitat	Little Klickitat	Swale Creek	Lower Klickitat	Columbia Tributaries
Developed	0%	0%	2%	0%	0%	2%
Barren	9%	8%	4%	0%	2%	0%
Vegetated; Natural Forested Upland	83%	85%	57%	11%	75%	6%
Shrubland	3%	1%	20%	47%	11%	50%
Grasslands/Herbaceous	3%	1%	7%	8%	9%	27%
Planted/Cultivated	0%	4%	11%	33%	2%	2%
Other	1%	0%	0%	0%	0%	11%[1]

1/ Includes lands inundated by Columbia River reservoirs

3.0 WATER QUANTITY

3.1 SURFACE WATER PRESENT IN THE WRIA

The variations in the elevation ranges of the subbasins found within WRIA 30 result in variable expected runoff patterns among the subbasins. Streams within the Upper Klickitat subbasin and the Klickitat River mainstem itself are likely to have a snowmelt-dominated hydrograph, with the highest flows occurring in the late spring months. In the mid-elevation ranges, streams are likely to have rain-on-snow dominated hydrographs, with the highest flows occurring in the winter months during relatively warm winter storms. In the lowest elevation areas streams are typically not influenced by rain-on-snow events, and are likely to have a rainfall driven hydrograph, with the highest flows occurring in response to high-intensity rainfall events.

The gentle relief of a large portion of the WRIA limits the potential energy available to move water through the system, resulting in relatively low stream velocities and erosion potential, and allows for precipitation to percolate to aquifers. Conversely, areas of steeper relief (found primarily in the Upper Klickitat subbasin and within steep canyon areas) have greater erosion potential and a greater propensity for moving water out of the system.

3.1.1 Stream flow Estimates

Stream flow values were estimated from the 15 Unites States Geological Survey (USGS) stream gages that have been deployed in WRIA 30 (Figure 3; Appendix A, Chapter 2). Most of the stream flow gages in WRIA 30 are no longer active and it is uncertain whether stream flow records that ended 20 years ago are representative of current conditions.

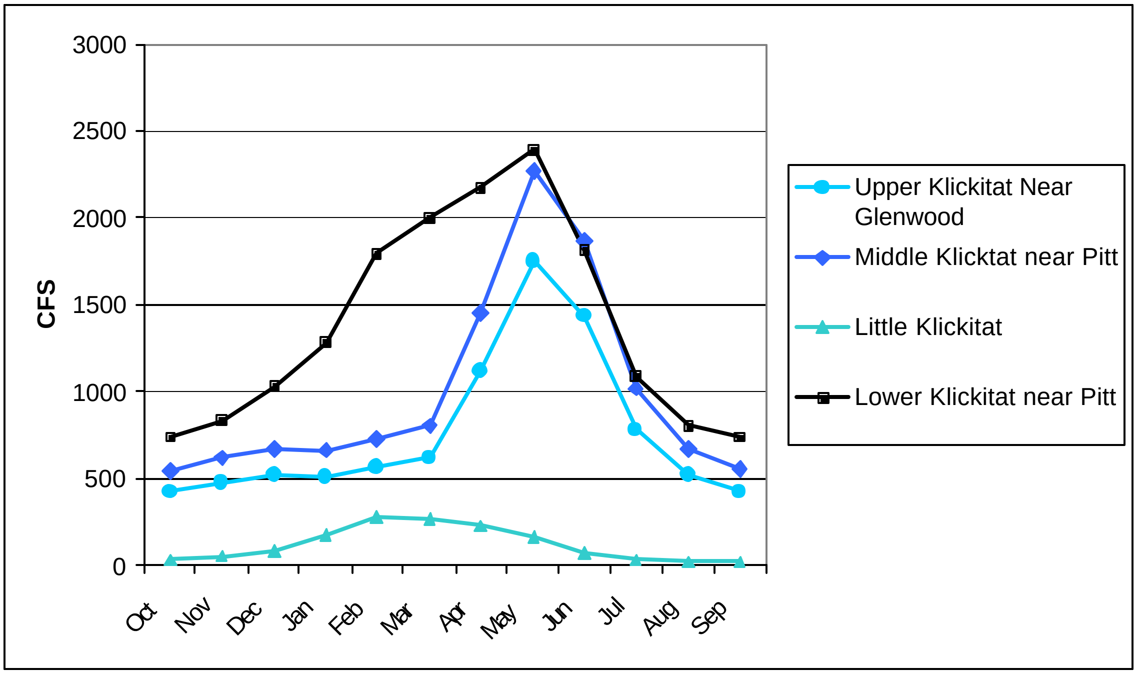

Figure 3. 50 percent exceedance flow estimated at three locations on the mainstem Klickitat River and for the Little Klickitat River.

Well documented cycles of relatively warm/dry and cold/wet weather in this area persist over periods of 20 to 30 years and are called the Pacific Decadal Oscillation, or PDO. Much of the data from gages in WRIA 30 were collected during cold/wet periods; hence averages of this data will tend to be more representative of wetter periods of time. At the time this report was prepared, the PDO cycle was transitioning into a cold/wet period. Water use and land use changes can also make it difficult to use old data to infer current conditions. It is noteworthy that the City of Goldendale has made major changes in its water supply sources in the last 2 years. The City has discontinued its diversion of water from Bloodgood Springs (a tributary to the Little Klickitat River) and is now using groundwater from the Simcoe Mountain volcanics north of Town and Wanapum basalt aquifer in the Swale Creek Basin. Curtailment of diversion from Bloodgood Springs will provide increased flow in the Little Klickitat River, particularly during low-flow periods; however, no data exists to document the magnitude of this change.

For the purposes of this assessment, a statistical trend analysis was performed to determine if significant time trends exist for mean annual flow and annual low flow at two representative locations with longer-term data records. No significant trends over time were detected in the mean annual stream flow data at the two representative locations (i.e., the Little Klickitat River gage near Wahkiacus and Klickitat River gage near Pitt) evaluated in this assessment. In addition, when precipitation was factored out, there were also no significant time trends in mean annual stream flow at either location.

Snowmelt from Mount Adams contributes water to the Klickitat River in its upper reaches, which sustains flows in the mainstem through the dry summer months. There are no apparent long-term trends in total annual discharge of the Little Klickitat River at Wahkiacus. However, a significant declining trend in annual low flows was observed at this location (Figure 4). This observed trend may be at least partially due to additional climatic variables not accounted for (e.g., decadal cycles in precipitation, air temperature, snow pack), land use effects on water yield, increases in consumptive water use, or some combination of the above.

Stream flow records in the other subbasins were of insufficient duration or quality to evaluate trends.

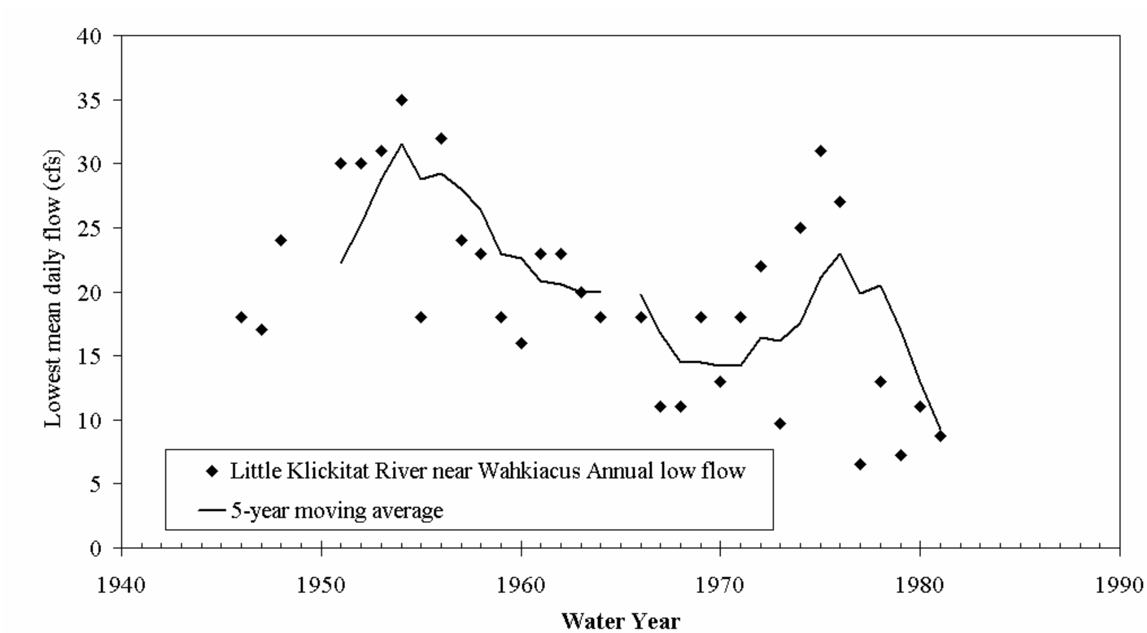

Figure 4. Annual low flows at the Little Klickitat River gage near Wahkiacus.

3.1.2 Peak Flows

Estimated peak discharges at USGS stream gages within WRIA 30 were calculated. These values are the most recent available for the area. The February 8, 1996 event was the largest flood event on record (40,000 cfs) (Table 2). The 1996 event was estimated to be an 87 year event. Other major events occurred in 1974, 1964, and 1933. Each of these events exceeded the estimated 10 year flood event flow of 20,500 cfs near the mouth of the Klickitat River (near Pitt).

3.2 GROUNDWATER PRESENT IN THE WRIA

The groundwater characteristics of the principal geologic units in WRIA 30 (Appendix A, Chapter 5) are discussed briefly below (from oldest to youngest).

Grande Ronde Basalt. Relatively few wells within WRIA 30 produce groundwater from the Grande Ronde Basalt, and those that do are typically deep wells (greater than 400 feet deep) used for irrigation in the southern watershed. Groundwater in the Grande Ronde beneath most of the watershed (Middle Klickitat Subbasin and south) regionally flows toward the south with discharge to the main stem Klickitat River and the Columbia River.

Table 2. Ten largest peak flow events on record (7/1/1909-1/31/1912 and 10/1/1928-9/20/2002) recorded at the USGS gage on the Klickitat River near Pitt.

Date	Daily Mean Flow
2/8/1996	40000
1/16/1974	39000
12/22/1933	23500
12/23/1964	22800
2/21/1982	18900
1/2/1997	18600
12/22/1955	16500
2/10/1961	16000
1/21/1972	14300
2/1/1995	13600

Based on regional assessment of structural controls (folds and faults) in the basalts, The Warwick Fault, which bisects the western portion of Swale Creek valley at Warwick, forms a structural closure to the Swale Creek valley creating an impoundment of groundwater to the east of the fault.

In the Goldendale area and immediately north, deep wells completed in the Grande Ronde have had water quality unsuitable for potable use (mineralized water with high total dissolved solids and localized presence of hydrogen sulfide). Based on limited exploration, groundwater quality in this unit appears to be moderate to good within the Swale Creek subbasin south of Goldendale. The observed differences in Grande Ronde water quality across the watershed are likely attributable to the source and amount of recharge to the unit. Little information regarding groundwater in the Grande Ronde is available for the northwestern portion of the watershed.

Wanapum Basalt. The Wanapum Basalt is typically the largest source for groundwater supply, particularly for large irrigation and municipal withdrawals, across the mid and southern portion of WRIA 30. Groundwater in the Wanapum regionally flows toward the southwest, but a significant east-west trending groundwater divide occurs along an unnamed anticline separating the Goldendale area (to the north) from the Centerville area (to the south). From this groundwater divide, groundwater flows in the basalt northward to the Little Klickitat River and southward to the Swale Creek valley. Groundwater in the Wanapum flows into the Swale Creek valley from the north and south. As discussed above for the Grande Ronde, the Warwick Fault creates an impoundment of groundwater in the Wanapum Basalt to the east.

Groundwater quality in the Wanapum is variable depending on location and depth, but is generally suitable for most, if not all, uses. In the central region of the basin near Goldendale, the available data suggest that total dissolved solids (TDS) increases with depth.

Quaternary Volcanics. Within the Little Klickitat subbasin, the Quaternary-aged Simcoe Volcanics, forming the Simcoe Mountains, represent an important source of groundwater. The Simcoe Volcanics have many flows with a coarse, open texture that permits rapid recharge and good vertical and lateral movement of water. Because of the high permeability of some zones in the Simcoe Volcanics, they can provide large quantities of groundwater. The City of Goldendale recently completed a new municipal supply well in this unit to replace the City's historical source of supply from the Bloodgood Springs. The majority of the documented springs in this subbasin discharge from the Simcoe Volcanics, often feeding the numerous tributary streams to the Little Klickitat River. Groundwater quality in the Simcoe Volcanics is typically exceptional. Groundwater in the Quaternary Volcanics of the Camas Prairie region (Middle Klickitat Subbasin) flows toward the northeast, discharging to large springs along tributaries to the Klickitat River (e.g., Outlet Creek).

3.3 RECHARGE OF GROUNDWATER AND SURFACE/GROUNDWATER INTERACTIONS

3.3.1 Groundwater Recharge

Groundwater recharge within WRIA 30 (Table 3) occurs primarily through the infiltration of precipitation (both rain and snowmelt), and secondarily as seepage from surface waters and from anthropogenic affects (e.g. return flows from irrigation and septic systems) (Appendix A, Chapter 5).

The USGS estimated pre-development recharge by converting current commercial/industrial, irrigated agriculture, and dry land agriculture land uses to pre-development land uses (sage, forest, grassland, sand/barren). Based on the modeling results, recharge for the current land use is nearly 60% greater than under pre-development land uses, primarily as a result of irrigation return flows.

Table 3. Estimated Annual Recharge Volumes by Subbasin

Subbasin	Area (acres)	Ave. Annual Recharge Rate (inch/yr)	Ave. Annual Recharge Volume (acre-ft/yr)	Relative % Contribution to Recharge
Upper Klickitat	224,113	15	280,000	33%
Middle Klickitat	298,831	14	345,000	41%
Little Klickitat	179,195	7	109,000	13%
Swale	80,490	4	26,000	3%
Lower Klickitat	82,111	10	69,000	8%
Columbia Tribs	58,155	3	12,000	2%
WRIA 30 Totals	**922,915**	**-**	**841,000**	

3.3.2 Groundwater Discharge

Annually, water (rainfall and irrigation water) percolates through soils and into groundwater. This is known as groundwater recharge. Most of the groundwater recharge in WRIA 30 ultimately discharges to surface waters within the watershed; however, some groundwater both enters and exits the watershed via deep flow systems (Appendix A, Chapter 5). Springs are the most obvious indication of groundwater discharge locations. Although the data on spring locations are somewhat coarse and do not cover the upper half of WRIA 30 (all of Upper Klickitat and part of Middle Klickitat Subbasins), some general patterns are apparent.

- A relatively large number of springs occur in and around the Camas Prairie region of the Middle Klickitat Subbasin. Several of these springs are large in magnitude, and stream flow increases of 100 cfs as a result of major spring discharges have been documented in this area.

- In the Little Klickitat Subbasin, the majority of the documented springs discharge from the Quaternary Volcanics, often feeding tributary streams to the Little Klickitat River. Much of this discharge is fed by snowmelt in the Simcoe Mountains, and has a short residence time in the aquifer prior to discharge. Springs of note are Simcoe Springs, within the subbasin headwaters, which serve as the City of Goldendale's principal water supply. Bloodgood Spring, lower in the subbasin, likewise has historically served as a water supply for Goldendale. Many of the other tributaries on the north side of the Little Klickitat River also initiate at springs.

- The few springs mapped in the Lower Klickitat Subbasin appear to emanate from the Wanapum Basalt. Springs are not mapped discharging from the Grande Ronde Basalt where the Klickitat River has eroded down into it.

- Relatively few springs are mapped in the Swale Creek Subbasin. They are within or near the alluvial fill near Centerville. A few small springs were also observed discharging from the basalts within Swale Canyon during an April 2003 field reconnaissance. One spring near Stacker Canyon has an estimated summer flow of 0.25 to 0.5 cfs. None of the other observed springs had significant discharge.

- Few springs are mapped within the Columbia Tributaries Subbasin; however, groundwater is known to discharge to the Columbia River.

3.3.3 Groundwater Conditions and Hydraulic Continuity by Subbasin

There are varying degrees of hydraulic continuity between groundwater and surface water depending largely on the horizontal and vertical position of the groundwater aquifer relative to the surface water body and the presence or absence of low-permeability materials or structural controls between the two. In WRIA 30, groundwater in areas of shallow alluvial aquifers typically has significant hydraulic connection with all classes of streams as well as rivers (Appendix A, Chapter 5). Conversely, groundwater in deeper basalt aquifers may have limited connection to headwater streams and principally discharges to the major, lower elevation drainages including the mainstem of the Klickitat and Columbia Rivers as well as smaller streams.

Groundwater in the Quaternary Volcanics west of the Klickitat River likely discharges to the Klickitat River, although no hard data are available to assess the degree of hydraulic continuity.

The Middle Klickitat River Subbasin includes the Camas Prairie region west of the Klickitat River and, east of the river, the Summit Creek drainage. The Camas Prairie consists of a large expanse of alluvium with thickness of up to 160 feet, which was deposited in a synclinal trough of the underlying Quaternary Volcanics. Shallow wells (including dug wells) in the alluvium are common, with small to moderate yields depending on the permeability of the alluvium. A few wells tap the deeper basalt aquifers.

As a result of the abundant shallow groundwater in the region, springs are common in the Camas Prairie (Glenwood) area. Documentation of substantial spring discharge to local streams demonstrates direct hydraulic continuity between shallow groundwater (alluvium) and streams in this portion of the Middle Klickitat Subbasin.

The Summit Creek drainage, east of the Klickitat River, is incised within the Quaternary Volcanics, but there is little information (no well records) regarding groundwater resources in this area.

Groundwater production in the Little Klickitat River Subbasin occurs primarily from the Wanapum Basalt and, north and west of Goldendale, from the younger Simcoe

Volcanics. A few deep wells also tap the underlying Grande Ronde at depths of 900 feet or more. Available geologic data indicate that the Wanapum Basalt extends to depths of roughly 750 feet in the Goldendale area. Yields from this aquifer are normally less than 500 gpm, with a few of the deeper wells capable of producing greater than 1,000 gpm. Several wells north and west of Goldendale produce groundwater of excellent quality from the Simcoe Volcanics. In addition, spring discharge from the Simcoe Volcanics, within the Simcoe Mountains, provides the City of Goldendale's primary municipal water supply.

Similar to Camas Prairie, the Swale Creek subbasin is an alluvium-filled basin within an east-west trending synclinal trough of the Wanapum Basalts, in the area surrounding Centerville. Alluvial deposits have filled the depression over an area measuring approximately 3 miles wide and 8 miles long, with depths to bedrock along the axis of Swale Creek greater than 200 feet near Centerville. Groundwater in this basin occurs within both the alluvial deposits and the underlying Wanapum and Grande Ronde Basalts. The principal uses of groundwater in the Swale Creek subbasin are irrigation and domestic supply. Many of the older irrigation wells are also open to the alluvial deposits. In recent years, use of some of these shallow irrigation wells has diminished in favor of deeper wells. The domestic wells generally obtain water from the alluvial aquifer or a combination of the alluvial aquifer and the underlying Wanapum Basalt.

The presence of surface water flow in the central portion of Swale Creek, between Highway 97 on the east and the Warwick area on the west, is ephemeral or of a seasonal nature directly related to the groundwater level in the surrounding alluvium. In early spring groundwater levels in the alluvium are generally high (shallow depth below the ground surface). Localized flooding of the low-lying areas around Swale Creek has reportedly occurred during particularly wet periods in the late winter and early spring. This portion of the creek is generally dry by late spring/early summer and for the balance of the year as groundwater levels in the alluvium decline.

The Warwick fault on the western margin of the Centerville valley impedes westerly groundwater flow within the basalt aquifers, and thus impedes groundwater contribution to the Swale Creek Canyon (west of Warwick). This geologic control on groundwater discharge is confirmed by low summer surface water flows and lack of any significant springs within Swale Creek Canyon.

The Lower Klickitat River Subbasin encompasses the area between Wahkiacus and the river's discharge to the Columbia River at Lyle. Groundwater in this region is produced primarily from the Wanapum Basalt. In the highlands west of the Klickitat River, groundwater is typically produced from shallow wells tapping the Wanapum Basalt, but yields are generally low. In areas where the Klickitat River valley is wider, some shallow wells produce from recent alluvial gravels. Groundwater in the alluvium is expected to have direct hydraulic continuity with the river. Springs commonly discharge from the basalts along the walls of the Klickitat River valley in this subbasin. Wells drilled to depths of 200 to 300 feet in this area have historically flowed at the surface due to naturally occurring pressure. It is hypothesized that this groundwater has migrated upward from deeper basalt zones via faults. The locations of springs adjacent to some streams in the subbasin indicate hydraulic continuity between groundwater in the Wanapum Basalt and surface waters of the subbasin.

Within the Columbia Tributaries subbasin, groundwater is used primarily for municipal, domestic, and limited industrial supplies; the bulk of the irrigation and industrial water supply is obtained from the Columbia River. In the western half of the subbasin, springs discharging from the basalt provide small water quantities for domestic or stock watering purposes. However, most of the groundwater in this area is obtained from wells. Wells completed in close proximity to the Columbia River can be highly productive, owing largely to their direct hydraulic connection with the river.

3.4 WATER RIGHTS

The current status of water appropriations in the watershed was determined through an examination of existing water right permits, certificates, claims, and applications. However, actual water use often varies significantly from the amount of water appropriated under existing water rights in a basin. Therefore estimates of actual water use are also needed to assess the current water demand.

To help develop a preliminary understanding of the water quantity picture in WRIA 30, the quantity of water allocated for use through existing water rights in each Subbasin was summarized, based on available information from Ecology's Water Right Application Tracking System (WRATS) (Appendix A, Chapter 6).

Based on the WRATS database for WRIA 30, a total of 59,577 acre-feet/year of water is allocated by 881 water right certificates and permits (Table 4). Of this total quantity, the vast majority (77%) of water allocated within the watershed is for irrigation use (Figure 5). Water rights allocated for municipal, domestic, commercial/industrial, heat exchange, and railway uses collectively make up an additional 22% of the total. Water rights allocated for stock watering, fire protection, fish propagation, and wildlife propagation collectively make up less than 1% of the total. The majority of the water right certificates and permits are located in the Little Klickitat, Swale, and Columbia Tributaries Subbasins (Figure 6).

According to the WRATS, there are a total of 1,178 claims in WRIA 30 for a total of 91,062 acre-feet of water per year (Table 4). The overwhelming majority of water claimed is for irrigation use.

The WRATS database includes a total of 92 water right applications for new appropriations (groundwater and surface water) pending in WRIA 30. The cumulative rate of diversion/withdrawal encompassed by these applications is approximately 1,170 cfs. The largest number of applications, but not necessarily the largest quantities requested, is for irrigation use. Annual quantities are determined during the permitting process and thus not recorded for applications.

Table 4. Number of certificates and permits, claims, and applications for WRIA 30 and the acre-feet per year certificated, permitted, claimed, or applied for.

	Groundwater Certificates and Permits		Surface Water Certificates and Permits		Claims		Applications	
	Number	ac-ft/yr	Number	ac-ft/yr	Number	ac-ft/yr	Number	ac-ft/yr
Upper Klickitat	0	0	10	10	28	43300	0	0
Middle Klickitat	6	487	188	699	278	44590	5	202
Little Klickitat	181	18910	259	15136	182	1536	31	19
Swale Creek	58	11632	7	27	273	15	22	5.8
Lower Klickitat	15	217	67	3002	240	13	16	122
Columbia Tributaries	61	7997	29	1468	177	1608	18	821
Total	**321**	**39243**	**560**	**20342**	**1178**	**91062**	**92**	**1169.8**

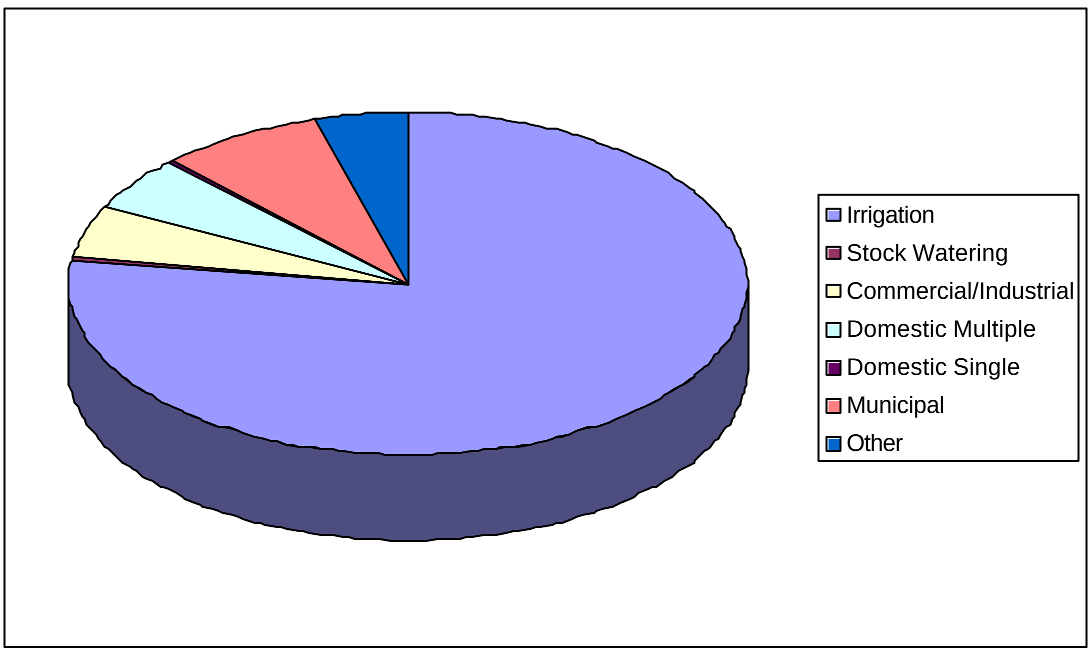

Figure 5. Distribution of the total allocated acre-feet per year of water across use.

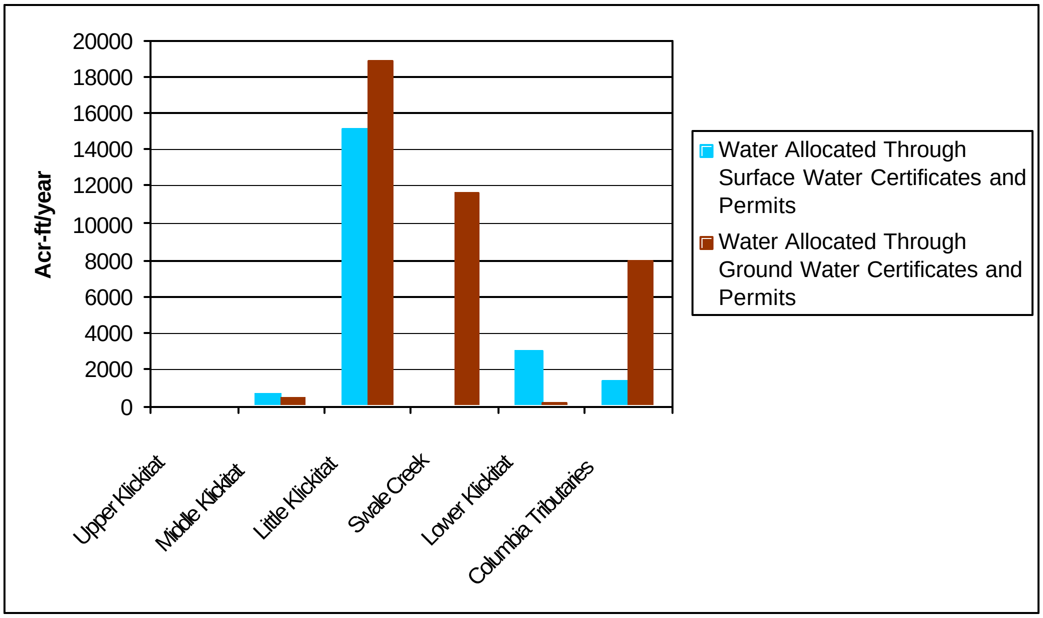

Figure 6. Surface and ground water allocated through certificates and permits in each subbasin.

3.5 WATER USE

Estimates of actual water use are important for comparison against appropriated ("paper") water rights and for developing a preliminary water budget for WRIA 30 (Appendix A, Chapter 6). Typically, actual water use will be lower than water right appropriations because water rights recorded in the WRATS may be inactive or development of the allocated resources may be constrained by a variety of factors. With the exception of the larger purveyors, water use has historically not been metered, although this is changing with promulgation of a metering rule (WAC 173-173) by Ecology As such, preliminary estimates of actual water use were developed for this Level 1 Assessment based on available information and numerous assumptions.

Table 5 summarizes water use estimates, by subbasin, for the various categories of use (irrigation, residential, and non-residential). Based on the results of this Level 1 Assessment, irrigation represents the overwhelming majority (approximately 92%) of the total water use in WRIA 30, which is consistent with the results of the water rights analysis. Residential and non-residential uses comprise roughly seven and one percent of the total water use, respectively.

Table 5. Estimated Total Water Use for WRIA 30 by Subbasin

	Estimated Water Use (Acre-Feet/Year) by Category				
Subbasin	Irrigation	PWS-Supplied Residential	Self-Supplied Residential	PWS Non-Residential	**Subbasin Totals**
Middle Klickitat	13,895	154	13	10	14,071
Little Klickitat	9,788	750	477	400	11,415
Swale Creek	5,729	3	19	0.1	5,751
Lower Klickitat	0	111	307	26	444
Columbia Tributaries	48	358	56	34	496
WRIA 30 Totals:	29,459	1,376	871	471	**32,177**
% of Total WRIA 30 Use:	92%	4%	3%	1%	100%

3.6 FUTURE DEMAND

Future demand is influenced by expected change in population, expected change in industrial/commercial uses, and expected change in existing water uses. At present, residential and non-residential water use is only 8% of the total water used in the WRIA. Irrigation uses consume 92% of the water used.

Population growth in Klickitat County is relatively slow. The U.S. Census Bureau estimated the total population in the County at 19,161 people. They have projected a county-wide population of 19,547 on July 1, 2003. This corresponds to an estimated growth rate of approximately 0.7 percent per year. Applying this rate of growth to the estimated population within the WRIA (11,705 people) over ten years, the change in population would be expected to be an increase by roughly 785 people. Applying the estimated water use per capita (2,247 acre-feet per year divided by 11,705 people), this increase in population projected over ten years would result in an increase in demand for residential water use of approximately 143 acre-feet per year. This increase in demand is very small relative to the quantity of water used for irrigation. Hence, future water consumption is likely to continue to be nominal relative to irrigation use.

At present, water consumed by commercial/industrial uses are only 1% of the total volume used in the WRIA. In the near future, a new energy is expected to go online in Goldendale. Estimates of water demand of this plant are not available. Additional future changes in commercial demand are unknown, but could change if additional industries move into the WRIA.

Irrigation use has been changing in the WRIA in recent years. The number of acres that are irrigated is believed to have decreased in some areas over recent years, based on input from local landowners. Hence assumptions had to be made regarding the number of irrigated acres. Additional assumptions had to be made regarding the amount of water used, return flows, and other factors affecting irrigation water use. As a result, there is considerable uncertainty in the irrigation water use estimates developed in the Level I assessment. Refinement of the irrigation water use estimates has been recommended for additional study. Future demand in irrigation is unknown. Demand will be affected by economic factors that cannot be predicted. Given that irrigation comprises the largest water use in WRIA 30, reliable estimates of future demand cannot be developed.

3.7 WATER AVAILABLE FOR ALLOCATION

Groundwater available for allocation cannot be quantified. Estimates of annual recharge are available (see section 3.3.1), however the quantity of groundwater discharged to streams is unknown in most areas (Appendix A, Chapter 6). Also the portion of the estimated irrigation use that is drawn from groundwater cannot be reliably estimated in some areas; hence the total amount available for allocation cannot be quantified. Groundwater appears to be abundant in the Camas Prairie (Glenwood) area and the Simcoe volcanics located in the northern portion of the Little Klickitat basin. The Wanapum basalts are also quite productive. The quantity of water available for allocation from these areas is, however, unknown.

Surface water available for allocations cannot be reliably determined due to uncertainties in actual water use and uncertainties regarding the quantity of water needed to provide for specified beneficial uses.

No estimates of water use were available for the Upper Klickitat basin. Recorded water right allocations are very small in the subbasin relative to stream flows. The recorded rights, however, do not include Federal Reserve rights. Hence, the total use of water in the subbasin is highly uncertain.

Total estimated annual surface water use in the Middle Klickitat subbasin is approximately 2 percent of the average annual 50% exceedance flow and annual groundwater use is slightly less than 0.1 percent of the total annual groundwater recharge volume. Total annual surface water allocations (including claims) are roughly 6 percent of the 50% exceedance flows, and groundwater allocations are approximately 0.1 percent of the annual groundwater recharge. Water use is concentrated from April through September, which includes the summer months when stream flows are naturally lowest. Current water use is estimated at roughly 30 percent of the summer 50% exceedance flow (Figure 7). There is substnatial uncertainty in the estimates of irrigation water in the middle Klickitat River subbasin. Given that irrigation comprises the largest water use in the subbasin, refinement of the irrigation water use estimates would help to improve those estimates.

The Little Klickitat has the second highest estimated water use in WRIA 30. The estimated annual surface water use is approximately 6 percent of the average annual 50% exceedance flow, and annual groundwater use is approximately 6 percent of the annual groundwater recharge. Annual surface water and groundwater allocations (excluding claims) are 17 percent of the 50% exceedance flows and annual groundwater recharge, respectively. The majority of the water use is in summer when flows are lowest (Figure 8).

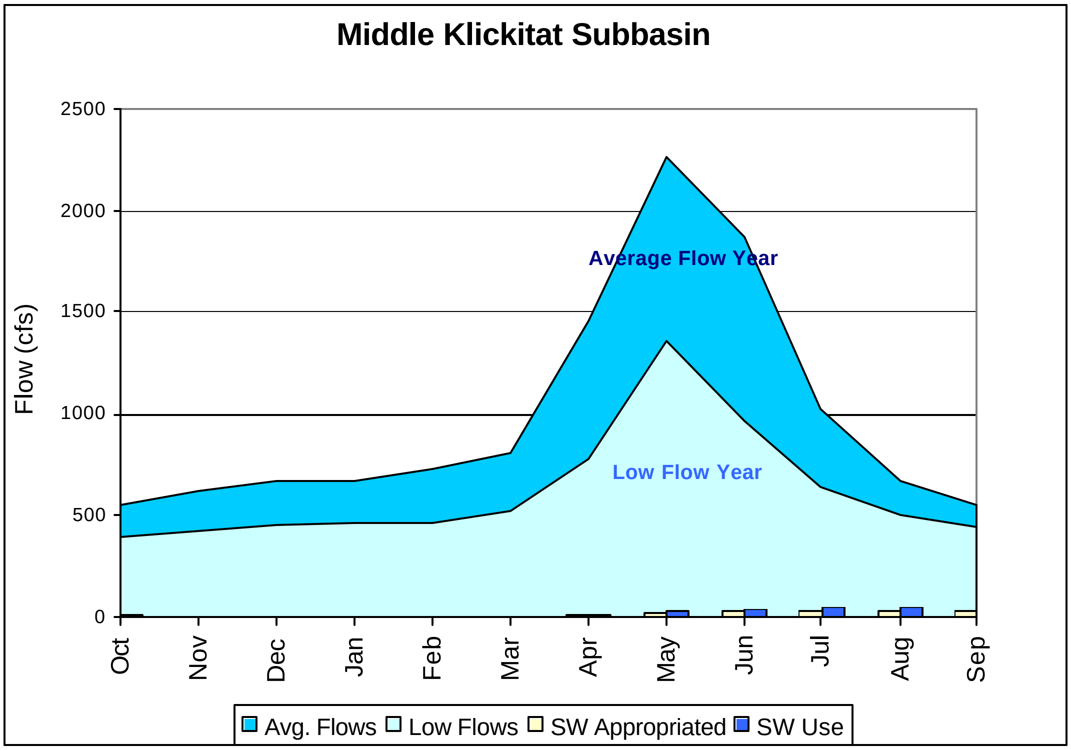

Figure 7. Total estimated surface water allocation and use in the Middle Klickitat Subbasin relative to the 50% and 90% exceedance flows.

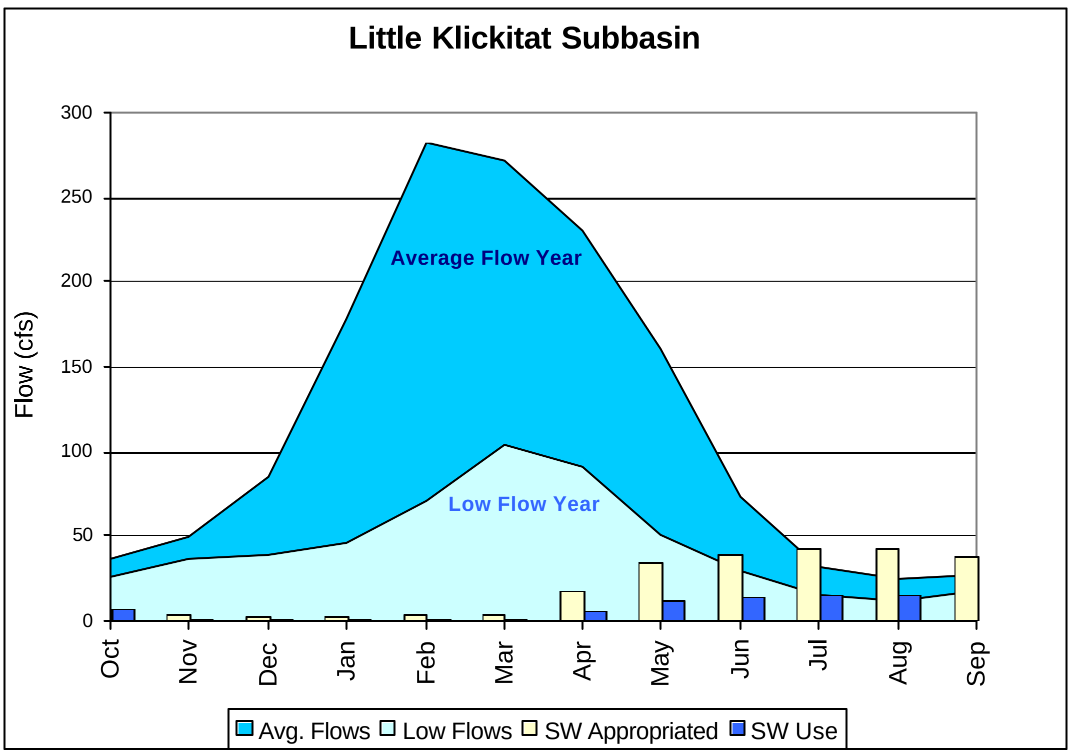

Figure 8. Current estimated surface water allocation and use relative to the 50% and 90% exceedance flows in the Little Klickitat subbasin.

As was discussed in previous sections, there is substantial uncertainty regarding the estimated irrigation water use in this subbasin.

Total water use within the Lower Klickitat River subbasin is negligible. The cumulative water use, which is the sum of the use within the subbasin plus water use in all subbasins upstream, is negligible in winter. In summer, estimated use is 7.3 percent of the 50 percent exceedance flow (which reflects the surface water withdrawals) (Figure 9).

Sufficient information was not available to develop water budgets for the Swale Creek and Columbia River Tributaries Subbasins. Most of the creeks in these subbasins are dry or near dry in summer; hence no surface water is available for allocation in summer months. However, groundwater in the underlying aquifers appears to be abundant (Appendices B and C).

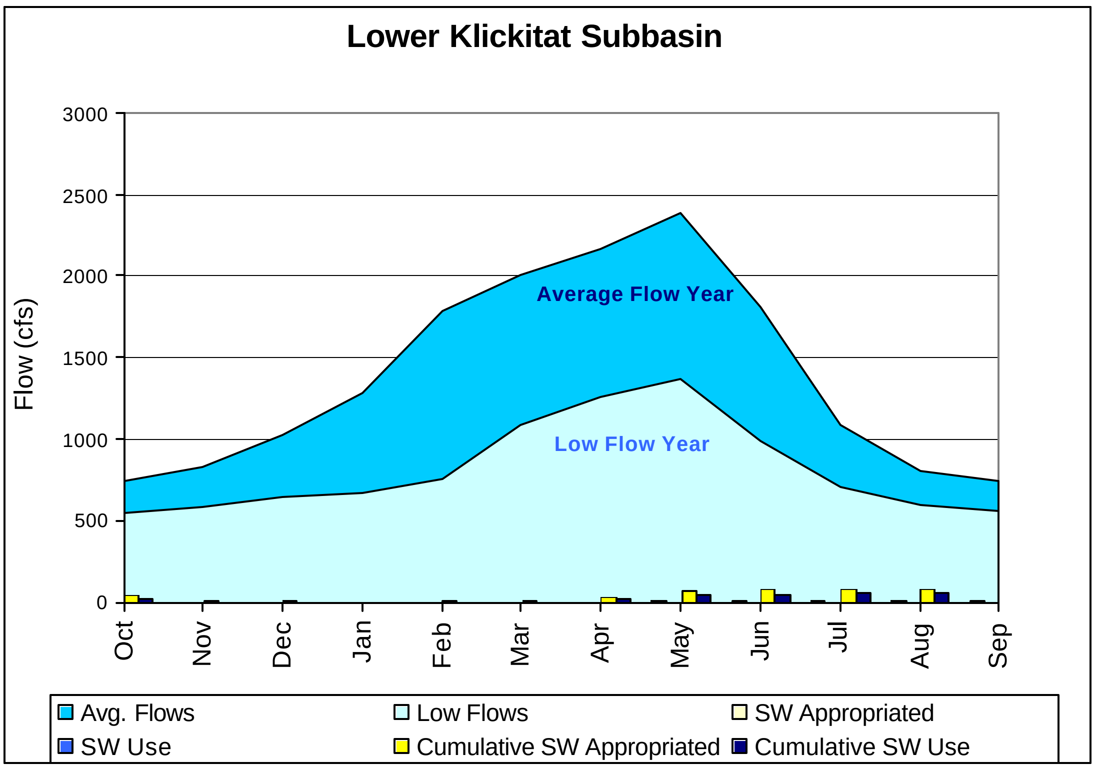

Figure 9. Exceedance flows, water allocation and water use within the lower Klickitat subbasin (values of use and allocation within the subbasin are too small to show on the plot), and total cumulative water allocation and use reflecting water use in the Lower Klickitat subbasin and all upstream subbasins.

4.0 WATER QUALITY

4.1 SURFACE WATER

Section 303(d) of the federal Clean Water Act requires Washington State periodically to prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next two years. The list of these waters is commonly referred to as the 303(d) list.

Nine streams and stream segments in WRIA 30 have been included on the 1998 303(d) list (Table 6). With one exception (Swale Creek), all of the listings are in the Little Klickitat Subbasin. The identified impairments include segments impaired due to temperature and those impaired due to low stream flows. It should be noted that some unmonitored streams or stream segments may fail to meet the state standards. In situations where data are not sufficient to determine whether standards are met, the streams or stream segments are not included on the 303(d) list. Details regarding water quality in WRIA 30 can be found in Appendix A, Chapter 4.

4.1.1 Middle Klickitat Subbasin

There were no water quality data sources or reports identified for the Middle Klickitat subbasin. Big Muddy Creek, a tributary to the West Fork Klickitat River, originates at the Rusk and Klickitat glaciers on the east flank of Mount Adams and Little Muddy Creek originates at the Wilson glacier. There are occasional natural glacial outburst floods that feed torrents of water and volcanic debris into Big Muddy Creek. Little Muddy Creek also carries a large volume of fine sediments due to the weathering of volcanic rocks and glacial action. During the warmest months, a sediment plume from these tributaries colors the Klickitat River from the West Fork to the Columbia River 63 miles downstream.

Table 6. 303(d) Listed Water Segments in WRIA 30 (1996 and 1998 listings)

Water body Segment ID.	Name (Township, Range, Section)	Subbasin	Parameters Violating Water Quality Standards	
			Instream Flow	Temperature
D95ML	Blockhouse Creek (04N, 15E, 17)	Little Klickitat	X	
XU61DO	Bloodgood Creek (04N, 16E, 17)	Little Klickitat	X	
TN94DB	Bowman Creek (05N, 14E, 35	Little Klickitat	X	
YU86SG	Butler Creek (05N, 17E, 17)	Little Klickitat		X

Water body Segment ID.	**Name (Township, Range, Section)**	**Subbasin**	**Parameters Violating Water Quality Standards**	
			Instream Flow	**Temperature**
AY21LB	Little Klickitat River (04N, 14E, 09) (04N, 15E, 28)	Little Klickitat	X X	X
AG85MX PW77VQ PU81CT	Little Klickitat River, East Prong (05N, 17E, 16) (05N, 17E, 10) (05N, 17E, 03) (05N, 17E, 09) (06N, 17E, 35)	Little Klickitat		X X X X X
XU61ED	Little Klickitat River, West Prong (05N, 17E, 18)	Little Klickitat		X
FF43IZ	Mill Creek (04N, 15E, 05)	Little Klickitat	X	
XN32HN	Swale Creek (04N, 14E, 19)	Swale Creek	X	X

4.1.2 Lower Klickitat Subbasin

The Lower Klickitat Subbasin is the area that lies below the confluence with the Little Klickitat. The water quality problems identified in the Lower Klickitat Subbasin are elevated stream temperatures, periodic high sediment loads, elevated fecal coliform bacteria, and nutrient loading. The bacteria source has been attributed to nonpoint pollution sources such as the home sites and related septic system and cattle that graze along the mainstem and tributaries. An analysis of stream temperatures relative to natural background temperatures has not been conducted. Hence, the degree of effect of land use on current temperature situations is unknown. There are no 303(d) listed segments for the Lower Klickitat subbasin as of the 1998 listing.

Dissolved oxygen also fails to meet the water quality criteria a large portion of the time during the late summer period. Recorded dissolved oxygen levels are, however, out of the range of lethal levels, although the lower dissolved oxygen levels may cause some stress in fish populations.

4.1.3 Little Klickitat

The Little Klickitat River flows in a southwesterly direction from the southwest flank of the Simcoe Mountains (elevation 5,823 feet) to its confluence with the mainstem of the Klickitat River (elevation 600 feet) just north of Wahkiacus. There are twelve segments of the Little Klickitat that are contained on the 303(d) list of impaired water bodies. This list is developed by Ecology in fulfillment of requirements under the clear water act. Six of these stream segments are listed due to exceedance of the state temperature criteria and the remainders are listed for low instream flows.

The State has the responsibility to develop or support a plan for addressing and correcting water quality problems on 303(d) listed streams. One tool used for developing strategies to improve water quality is the development of a Total Maximum Daily Load (TMDL), which includes an assessment of the problem, identification of sources of pollutants, and a plan to address the problem. A Technical Report supporting a TMDL for the Little Klickitat River was completed in July of 2002 (Brock and Stohr, 2002). A draft Detailed Implementation Plan was released in June of 2004 (Anderson, 2004).

In addition to the temperature TMDL, a TMDL addressing total residual chlorine and biochemical oxygen demand (BOD) discharges from the Goldendale Wastewater Treatment Plant was developed by Ecology in 1993 (Pederson, 1993). The TMDL did not set load allocations, but recognized that modifications to the treatment plant completed in 1984 addressed previously identified problems. The treatment plant has undergone significant changes since that TMDL was completed; hence the information in that TMDL is now out of date.

Surface water was tested for fecal coliform and nitrate content in 2003 (Appendix D). All nitrate samples were well below the state criteria. Elevated fecal coliform concentrations were found at one location in Blockhouse Creek and one location in Bloodgood Creek.

4.1.4 Swale Creek

Surface water was tested for fecal coliform and nitrate concentration in 2003 (Appendix D). All nitrate samples collected from surface water met the state criterion. Elevated fecal coliform concentrations were found in late summer in several locations within the basin. These samples were collected from pools during a period of no flow.

A segment of Swale Creek in Range 4N, Township 14E, Section 19 (at the mouth of the creek), is listed on Ecology's 303(d) list as impaired due to exceedance of water temperature criteria and flow. A water quality study was completed between June and December, 2003 to address the current water temperature situation in Swale Creek, a tributary of the Klickitat River in Washington, and to estimate the potential and natural temperature situation in the lower portion of the creek which runs through a canyon (Appendix E).

The temperature criterion of 17.5 ^{o}C was exceeded at all stations monitored in 2003. The state temperature standards indicate that adult and juvenile salmonids will generally be protected from acute lethality by maintaining temperature at or below 22°C (71.6°F). All sites monitored in 2003 exceeded 22 ^{o}C for one or more days. Inter-annual variability was not as high as expected. The differences between years were smaller than the differences within years.

Under current conditions, the upper two reaches of the canyon (covering roughly 9 miles) are largely dry, with isolated bedrock dominated pools. In this area, shade tends to be quite low around the pools (<25%). The lower 3 miles of Swale Creek (excluding the mouth), is continuously wet in summer, though flow is negligible (estimated at 0.25 to

0.5 cfs). Shade in the area is denser and reaches almost 100% in some areas. The lack of soils and water in Swale Creek downstream of Warwick is the primary limiting factor on the development of riparian vegetation.

"Potential vegetation" was estimated based on available soils and water, adjusted upwards where channel restoration may increase vegetative growth. Potential shade in the bedrock dominated reaches downstream of Warwick was estimated to be similar or slightly higher than current vegetation. Shade in the lower 3 miles of the stream is already high, but could potentially become higher. There also appears to be some potential for establishment of some large conifers in the lower reach.

The GLO surveys conducted from 1861 to 1872 indicate that vegetation in the area was either non-existent or "scattered". The lower 5 miles of the stream apparently had denser vegetation; however the vegetation in the deepest part of the canyon was also characterized as "scattered".

Flows in Swale Creek downstream of Harms Road are supported principally by runoff from numerous small tributaries draining the surrounding uplands downstream of Warwick (e.g., Columbia Hills and High Prairie). Groundwater discharge provides minimal baseflow to Swale Creek. Runoff from the adjacent uplands sustains Swale Creek flows into late springtime. Once the spring runoff is over, Swale Creek flows quickly diminish, leaving only intermittent flow and discontinuous pools within Swale Canyon. Because geologic structure (the Warwick Fault) limits groundwater discharge to Swale Canyon, the lack of groundwater baseflow into the canyon has existed for geologic time, unchanged by land use change within the subbasin. Information from GLO surveys conducted in 1861 and 1872 suggests that surface water hydrology in between Warwick and river mile 5 was similar to current conditions. Surveys in the lower 5 miles were conducted in April; hence they do not provide insight into summer low flow conditions.

The results of modeling of stream temperature suggest that the stream temperature could be reduced with increased vegetation by 2.4°C on average, with a maximum decrease at any location of 3.4°C. The model predictions suggest that the current temperature criterion (17.5 ^{o}C) may be met in some years in the lower 3 miles of stream where the riparian vegetation is at its maximum development. Predicted temperatures were in the range of 17.2 to 18.9 ^{o}C in this reach for average years and 20.9 to 22.9 ^{o}C for warm years. The use of the maximum potential shade in the model runs tend to reflect conditions several years after a disturbance event, such as flood or fire, but likely overestimates potential reductions in temperature on average. Problems were encountered in applying the *Heat Source* model in this situation. The model was applied in a situation that was outside of the data used to develop the model, which can potentially introduce substantial error. Therefore, the results of the modeling should be interpreted carefully.

4.2 GROUNDWATER

Most groundwater data were collected by water purveyors as part of their routine monitoring of water supply wells. Since the mid-1990s, one time testing of newly constructed residential wells has been required, and this testing provided another source of groundwater quality data. There is no large-scale ground water monitoring plan in place that can be used to evaluate potential effects of land use on ground water quality or long-term trends in water quality. The available data indicate that most groundwater and monitored water supplies are well within drinking water standards, although many aquifers have high concentrations of sediments and the alluvial aquifer in the Swale Creek and lower Little Klickitat subbasins have localized areas of elevated nitrate levels (Appendix A, Chapter 4; Appendix D). Higher concentrations of nitrate tend to be found in wells that tap the upper 150 feet of the aquifer. Wells with elevated nitrate concentrations are correlated with elevated chloride concentrations, suggesting a septic source for the nitrate.

4.2.1 Fecal Coliform Bacteria

The only fecal coliform data available in any of the groundwater reports and databases reviewed for the Level I Assessment were from a closed landfill site located immediately north of HWY 14 east of Dallesport. Of the 108 samples collected at the four wells in the Horsethief Landfill most (101) met the State drinking water standards and no fecal coliforms were detected. The remaining seven samples had fecal coliform concentrations ranging from two to 23 coliforms/100 ml (milliliter).

A Level II study conducted primarily in the Swale and Little Klickitat subbasins (but also included samples from the middle and lower Klickitat subbasins) found no detectable fecal coliform concentrations in groundwater samples drawn from wells (Appendix D).

In a past study, some elevated values for fecal coliform bacteria were measured in both the Bloodgood and Simcoe springs. Nine fecal coliform samples were collected at Bloodgood spring and 36 at Simcoe spring between 1980 and 1985. A more recent three-year study of the springs indicated that drinking water standards are met. No fecal coliform bacteria have been present in either spring and the maximum total coliform value measured was 23/100mL. Monitoring of these springs has continued and no bacteria had been detected for 10 years. Based on available information, contamination of groundwater from fecal coliforms does not appear to be a problem in WRIA 30.

4.2.2 Other Water Quality Parameters

The Washington Department of Health (WDOH) database contained 23 entries for copper and lead. The samples were taken from 21 public water systems all at different points of use (i.e. private residences, public and private buildings, waste water treatment plants, etc.) in 1993 through 2001. It appears that the majority of the samples were taken from a faucet or tap. The average concentration for the copper was 0.060 mg/L; none of the entries exceeded the State drinking water action level for copper (1.3 mg/L).

The average concentration for the lead samples was 0.002 mg/L; six entries had a concentration greater than the State drinking water action level of 0.015 mg/L for lead. It is likely these elevated concentrations are a reflection of the distribution system (i.e. pipes and plumbing) and are not representative of local groundwater quality.

Iron is a commonly occurring constituent of groundwater in Washington as it is derived naturally from the weathering of minerals within the aquifer. Iron is a secondary (aesthetic) contaminant to drinking water, with a water quality standard of 0.3 mg/L. Concentrations of iron above the standards are generally not considered a health problem, but it will impair the taste and can encrust plumbing and stain laundry. Although elevated concentrations of iron exist within the basin, none of the data sources reviewed for this study reported concentrations above the drinking water standard.

Deeper wells within the basin often have high total dissolved solids (TDS), manganese, and iron levels; however the majority of the domestic wells are located in shallow aquifers where mineralized groundwater is less prevalent.

There are aesthetic problems with source of water for the PUD operated water system for the community of Klickitat. Drinking water at that site meets health based standards but taste is affected and sediment is elevated.

5.0 FISH HABITAT

Actual data documenting fish population distributions, fish population size, and habitat quality within the WRIA are sparse within the published record (Appendix A, Chapter 3). A watershed analysis conducted in the upper Little Klickitat subbasin provided in-depth information for that portion of the WRIA. Another study provided geomorphic information regarding the Swale Creek Subbasin. Other published studies provided generalized descriptions or habitat conditions with limited reported data. Studies designed to document current fish distribution, habitat quality, and land use interactions with aquatic habitat are highly recommended to fill this information gap.

5.1 FISH POPULATIONS

Currently, there are three stocks of chinook (spring, tule, upriver bright), one coho, and two steelhead stocks (summer, winter) in the Klickitat watershed. Bull trout have also been found in the basin (Table 7). Winter and summer steelhead and bull trout have been listed under the Endangered Species Act as threatened.

Summer steelhead are known to be native to the Klickitat watershed. Winter steelhead were not observed in the basin before the early 1980s, but are presumed to have been present historically. Tule fall chinook and coho were introduced starting in the 1940s and early 1950s. Upriver bright fall chinook are also considered to be an introduced stock. They were first found in the basin in 1989.

The timing of the different life history phases for the anadromous species varies considerably by species and stock, however, adult and juvenile salmonids of one species/stock or another are present in the watershed year round.

Table 7: Klickitat River subbasin Salmon, Steelhead, Trout and Bull Trout - Stock Profiles.

Stock	Major Subbasin(s)	SASSI Stock Status	Stock Origin	ESA Status[3]
Spring Chinook	Lower, Middle Portions of Upper, Little & Swale Creek[2]	Depressed	Native - Mixed	
Fall (Tule) Chinook	Lower, Middle	Depressed	Mixed	
Fall Upriver Bright (URB) Chinook	Lower, Middle	Depressed	Non-native	
Summer Chinook	Lower, Middle	?	?	
Coho	Lower, Middle Portions of Upper& Little[2]	Depressed[1]	Mixed	
Winter Steelhead	Lower, Middle, Upper, Little & Swale Creek[2]	Unknown	Native	Threatened
Summer Steelhead	Lower, Middle, Upper, Little & Swale Creek[2]	Unknown	Native	Threatened
Bull Trout	Upper	Unknown	Native	Threatened
Coastal Cutthroat	Lower	Unknown	Native	

[1] Note coho were introduced to the watershed starting in the 1940s and early 1950s and are not a native. Stock depressed indicates that current numbers are lower than previous years.
[2] Distribution is limited to the lower 14 miles of Swale Creek. Distribution of chinook and coho in the Little Klickitat is limited to the lower 6.1 miles of the stream. Passage of steelhead upstream of river mile 6.1 in the Little Klickitat is uncertain, see text.
[3] ESA status as of April, 2004

5.2 PASSAGE BARRIERS

One of the major limitations on anadromous fish production is the presence of a number of natural migration barriers in the watershed. The Klickitat River flows through a deep, steep walled canyon with impassable or marginally passable falls and cascades where the river flows over more resistant bedrock. In addition, access to many of the tributaries is restricted because there are impassably high gradients close to the tributary mouths. The following provides brief descriptions of the most significant natural fish passage barriers and impediments:

Lyle Falls (RM 2.2) is currently not a barrier to any salmon or steelhead stocks, but passage at the falls is considered difficult.

Castile Falls (RM 64.0) is a series of 11 falls with an elevation change of 80 feet over one-half mile. These falls are considered the historic upper limit of anadromous fish usage on the mainstem Klickitat River.

Little Klickitat River Falls (RM 6.1) is considered to be passable by steelhead under some flow conditions. The frequency that the falls is passable is unknown, and probably requires a larger flow event to enable passage. Redds, believed to be steelhead redds, were documented upstream of the falls in 1996 and 1997. Flood events in these years were the highest and sixth highest events on record in the mainstem Klickitat River. The relative magnitude of these events in the Little Klickitat River is unknown because no flow data was available for the river in those years.

West Fork Klickitat River Falls (RM 0.3 & 4.6) is 15 to 20 foot falls 0.3 miles upstream of the confluence with the mainstem of the Klickitat River. The falls was likely a passage barrier.

Tributary Falls: Numerous tributaries in the WRIA, such as Outlet Creek and Blockhouse Creek, have falls that block passage into upstream habitats.

Culverts: At least 49 culverts have been identified as total or partial barriers to fish passage in WRIA 30. Locations of these culverts have not been reported. Some of these culverts may be within the Yakama Indian Reservation. The portion of the culverts that are total barriers to anadromous fish passage is unknown.

5.3 HABITAT CONDITIONS

5.3.1 Middle Klickitat Subbasin

There was little specific information available regarding habitat in the Middle Klickitat subbasin. Much of the Klickitat mainstem within this subbasin flows through the Klickitat Wildlife area. Disturbances of habitat are largely limited to grazing and a road adjacent to the mainstem. Some minor development has occurred along the lower reaches. The Klickitat hatchery is also located within this subbasin. The highest density of *O. mykiss* (steelhead and/or rainbow trout) was found in the middle Klickitat area (Appendix A, Chapter 3).

5.3.2 Little Klickitat Subbasin

This watershed is on the drier side of the Klickitat basin. Here there is less snow pack for runoff and streams tend to have lower flows. Additionally, water temperatures tend to be warmer. Summer low flows are low enough that there are areas of intermittent flow preventing fish movements through the mainstem Little Klickitat during portions of the year.

Downstream of the Little Klickitat Falls (river mile 6.1), the river is generally low gradient (approximately 1.3 percent) with a cobble bottom. The dominant habitat in the lower reaches is pool/glide habitat. Further upstream, near river mile 9.6, the stream gradient is roughly 0.8 percent and gravel and cobble dominate the substrate. Some diking and channelization has occurred between river miles 10 and 18. There are parcels along the main Little Klickitat with grazing above river mile 12 and more extensive rural residential developments above river mile 17.4. These land uses impact riparian conditions and floodplain development. North of the town of Goldendale, Highway 97 parallels the stream resulting in some floodplain encroachment.

In 1999, a watershed analysis was completed which covered the portion of the Little Klickitat watershed upstream of the town of Goldendale. The analysis found a lack of suitable sized spawning gravels. Many of the stream channels had large substrates which appeared to be subject to scour at high flows. In addition many of the lower elevation reaches near the Mainstem of the Little Klickitat River had documented high temperatures. Also noted was a high degree of channel entrenchment, general lack of large woody debris, and limited pools and off channel refuge areas. The upper Little Klickitat, lower East Prong and portions of upper Butler had fair to good large woody debris, pools, and off channel refuge areas. The analysis also found erosion from roads and skid trails resulted in sediment inputs at high enough levels to impact incubation success. Since this analysis was completed, considerable effort has gone into addressing impassable culverts and surface erosion from roads.

Information regarding the tributaries downstream of Goldendale is sparse. Blockhouse Creek has a 56-foot falls between river mile 0.1 and river mile 0.2. A canyon extends upstream for a distance of 1.8 miles. Bowman Creek runs through a canyon from the mouth to river miles 2.6. Limited information regarding habitat quality is available at three sites. This information suggests that habitat was in relatively good condition at all three sites. Mill Creek also runs through a canyon in the lower 2.6 miles. Gradients in this creek are moderately steep (4.1 to 5.2 percent). Bloodgood Creek has an average gradient of 2.2 percent. At river mile 2.2, it is 10 to 12 feet wide with a sand and gravel substrate and heavy riparian vegetation. Spring Creek has a number of cascades between river mile 0.1 and 0.2 and has an average gradient of 1.1 percent. The substrate at river mile 0.7 is gravel and mud. Thick riparian vegetation is present at that site.

The Washington State Department of Ecology completed an IFIM study for the Little Klickitat River and the tributaries listed above. This study addressed spawning, juvenile, and adult habitat for coho, chinook, steelhead, and rainbow trout. No instream flows have been set as a result of this study. The results of the study indicate that virtually all the species included in the evaluation would be benefited by higher summer flows in the Lower Little Klickitat River, Mill Creek, and Bowman Creek.

5.3.3 Lower Klickitat Subbasin

Little habitat data is available for the Lower Klickitat subbasin. Lyle Falls, located at river mile 2.2, creates difficult passage for salmon and steelhead stocks entering the Klickitat River. The road SR 142 and an abandoned rail line encroach in the floodplain along much of the Mainstem Klickitat.

In the Snyder Creek watershed at the old lumber mill site, a 2400 foot concrete sluiceway forms a depth and/or velocity barrier to all anadromous species. Three or four miles of high quality habitat for coho and steelhead are above the barrier. A major passage restoration project is currently underway which is expected to provide upstream passage past the old mill.

5.3.4 Swale Creek Subbasin

Swale Creek flows through the driest portion of the watershed. During summer, stream flow is reduced to and estimated flow of 0.25 to 0.50 cfs (Appendices B and C) and stream temperatures exceed 23°C annually (73.4°F) (Appendix E). This reduces available habitat to a series of isolated pools. The lower 12 miles of the stream appears to contain good spawning habitat (WSCC 1999), however summer habitat in this portion of the stream has little flow and is isolated from the mainstem of the Klickitat River. A railroad bed, which was constructed in 1902, confines channel primarily in the 4 miles downstream of Warwick. The presence of the railroad bed also affects riparian growth in areas where the bed encroaches on the channel.

5.3.5 Columbia Tributaries Subbasin

No information on the Columbia tributaries was available in the reviewed documents. Generally, the tributaries tend to be steep streams. Most are dry or have little flow in the summer. They are unlikely to contain significant fish habitat.

6.0 DATA GAPS

HIGH PRIORITY DATA GAPS

The following data gaps and considerations reflect the areas of uncertainty that have the greatest potential to affect interpretation of data (Appendix A, Chapter 8). Other data gaps and considerations are discussed following this section.

- **Fish Passage into Little Klickitat Subbasin:** There is little known about how often the falls at river mile 6.1 is passable for steelhead or other migratory fish species. An in-depth study of passage at this falls should be considered to assess the frequency (number of years) that this falls is passable.

- **Assess contribution of groundwater baseflow:** There are limited data to assess the level of hydraulic continuity of groundwater to surface water within the WRIA. The current understanding is based on mapping of the extent and elevation of geologic units and springs relative to surface water drainages, and regional water level data collected over 20 years ago and subsequent Level II studies conducted in 2003 in the Swale and Little Klickitat subbasins. Additional data collection should be considered to enhance our understanding of the extent of groundwater - surface water interaction and contribution of baseflow. Such studies would be most beneficial within the eastern half of the WRIA (Little Klickitat River and Swale Creek subbasins).

  Additional data collection to consider:

  - Implementation of a groundwater level monitoring program within these two subbasins, as a first priority. A monitoring network would include wells within each of the principal aquifer zones to provide sufficient spatial coverage to help refine regional groundwater flow conditions both within and between aquifer zones.

- Evaluation of the effect of changes in channel morphology in Swale Creek on summer base flows. Primary focus would be on changes that occurred upstream of Warwick and the effects that those changes may have had on base flows in Swale Creek Canyon.

- **Stream Temperature in 303(d) Listed Streams**: Several stream segments are listed for violations of the State water quality criterion. These include stream segments in Butler Creek, the Little Klickitat River, East Prong Creek, West Prong Creek, and Swale Creek. The State water quality standards include the numeric criteria plus a narrative standard that defaults to the "natural background temperature" where the criterion is naturally exceeded. Estimate natural background temperatures in Swale Creek likely exceed the state criterion (Appendix E). Some information regarding natural background temperature in the Little Klickitat River was also developed as part of the TMDL activities. No data are available for other areas of the WRIA. Therefore, studies to assess the natural background stream temperature should be considered.

- **Stream Gage data**: During the assessment, there were only 3 gage sites that are operational. Two are near Glenwood and the third is near the mouth of the Klickitat River. As part of Level II studies, rough estimates of winter flows in Swale Creek were developed using generalized runoff relationships; however, the estimates are based on very little subbasin-specific data and thus have limited reliability for watershed planning. Permanently installing and monitoring a USGS style gage in Swale Creek should be considered. In addition, re-establishing gages in the Little Klickitat River and the mid-Klickitat mainstem should also be considered.

- **Improve Estimates of Actual Irrigation Water Use:** Irrigation water use is the overwhelmingly largest water use in WRIA 30, yet the Level 1 Assessment estimates of actual irrigation use have considerable uncertainty. Because changes in assumptions used to estimate irrigation use would have the greatest effect on a watershed-wide water balance, refinement of these assumptions is warranted.

- **Fecal Coliform Concentrations in Swale, Bloodgood, and Blockhouse Creeks:** One time sampling has identified elevated concentrations of fecal coliforms in these creeks. Additional sampling should be considered to document the nature and seasonal patterns of concentrations and to ensure that the samples collected accurately reflect the current situation.

- **Conservation District Stream Temperature Data:** The Central Klickitat Conservation District has collected extensive stream temperature data. These data were summarized for every fifth data of data collection. Stream temperature data collected from Swale Creek have been re-analyzed to include DAILY mean, minimum, and maximum temperature as well as the 7-day running means.

Considerations should be given to re-analyzing the balance of the data from the conservation district.

LOWER PRIORITY DATA GAPS

- **Middle Klickitat Water Quality**: There is little water quality data available for the Middle Klickitat subbasin. The community of Glenwood and land uses in the vicinity could potentially be impacting water quality. Water quality monitoring should be considered in this subbasin.

- **Fish Habitat Information**: Little numeric information has been documented regarding the quality of fish habitat in the watershed besides the information covering the upper Little Klickitat subbasin addressed in the WDNR Watershed Analysis conducted by Boise Cascade and some information reported by the Yakama Nation. Additional monitoring to characterize habitat conditions in the watershed and identify opportunities for habitat improvement should be considered.

- **Sediment Inputs**: The limited habitat data available suggests that spawning habitat may be impacted by sediment inputs in several areas. A study estimating the sediment inputs associated with various land uses and the background inputs to identify areas where reductions in sediment may be beneficial should be considered.

- **Lower Klickitat Water Quality Data:** Temperature and dissolved oxygen levels exceed state criteria. The available data were obtained from analyses of grab samples. Deployment of continuous recording water quality instruments to better characterize stream temperature and dissolved oxygen in the lower mainstem Klickitat River should be considered. Data analysis should include DAILY mean, minimum, and maximum of the monitored parameters. Additionally, the 3-day and 7-day running means of temperature should be calculated.

- **Wetlands**: There is little information regarding the current and/or historic distribution and function of wetlands. Additional information would aid in assessing hydrologic effects of land use.

7.0 REFERENCES

Anderson, Ryan. 2004. little Klickitat River Watershed Temperature TMDL Detailed Implementation Plan. July 2004. Washington State Department of Ecology Publication Number 04-10-0XX.

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