Chapter 5 - Hydrology

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Introduction

This chapter of the watershed assessment will focus on hydrology: how human modification of the natural hydrology has impacted Pringle, Glenn-Gibson, Claggett, and Mill Creek watersheds. The various aspects of hydrology will be discussed as they relate to water rights and water use, land use, diversions of waterways, flooding and weather cycles, stream flows and aquatic use, in-stream use, and water level and water controls.

Data Sources

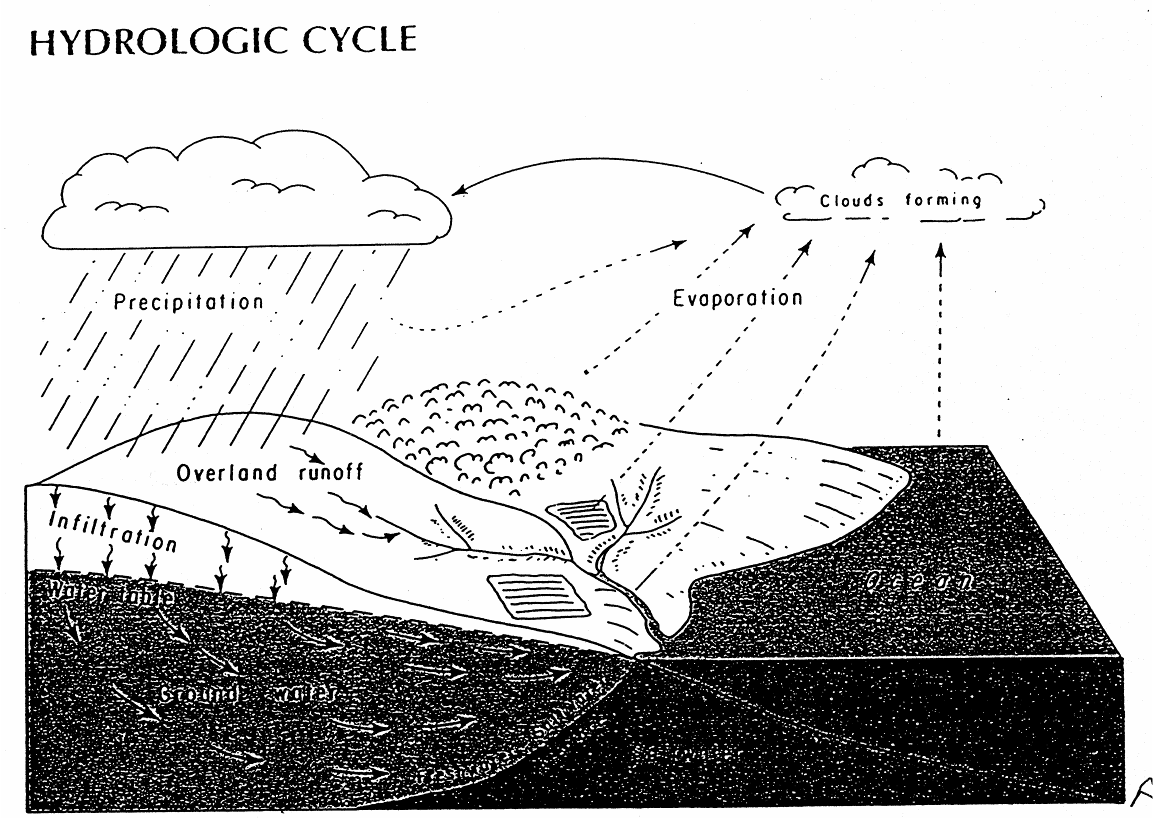
Data sources include Oregon Water Resources Department (OWRD), Oregon Department of Fish and Wildlife (ODFW), U.S. Geological Survey (USGS), City of Salem, Keizer Service District, Mid-Willamette Valley Council of Governments (MWVCOG), the Salem Public Library and Oregon Climate Service.

Hydrologic Cycle

The term hydrologic cycle is defined as the constant movement of water above, on, and below the Earth's surface (**Figure 5-1**). This drawing demonstrates how the cycle includes the following components: evaporation, precipitation, infiltration and overland flow. *Evaporation* occurs from vegetation, the ocean and other exposed moist land surfaces. The moist surfaces develop into clouds, which return the water to the land surface (i.e. oceans) in what is known as *precipitation.* The cycle is completed after precipitation, typically in the form of rain for the Willamette Valley, wets the surface and then enters the groundwater in a process called *infiltration.*

The rate of infiltration is not only dependent on the intensity or duration of rain but is also influenced by soil moisture, soil permeability and land use (Oregon State University Extension Service 2001). *Overland flow* occurs when the rate of precipitation exceeds the rate of infiltration. Water makes its way to streams both by ground-water discharge and overland flow, continuing the cycle as water is once again evaporated. This distribution and movement of surface and sub-surface water (i.e. hydrology) throughout all four of these watersheds is necessary for the protection of water quality, fish and wildlife habitat, and use of surface and ground-water. The City of Salem stores municipal water underground within city limits.

Figure 5-1. The Hydrologic Cycle



Source: Oregon State University Extension Services 2001

Why Streamflow is Important for Salmonids

Modifications to natural stream flows often diminish the capacity for a watershed to function properly, which may in turn threaten the viability of many fish populations. There are two significant problems associated with streamflow that may adversely impact salmonids. One is that high flows scour the channel and wash out the spawning gravels and redds. The other main factor is that decreased streamflows in the summer can limit the accessibility of juvenile salmonids to good habitat. In urban areas, stream flows are typically "flashy," meaning flows alternate between intense and short to longer durations of trickle-like flows. Both flow regimes place stress on salmonid species.

Although most species of salmonids appear to have adapted their life cycle to suit the specific flow patterns associated with their natal stream, increased winter flows can affect adult steelhead during their spawning and nesting times. For instance, during the winter months, salmonid swimming ability decreases as the water temperature decreases, which make the fish especially vulnerable to higher water velocities. As a result, over-wintering salmon typically seek areas of low water velocity such as marshes and wet meadows adjacent to the channel, or spaces formed between rocks along the channel. Loss of active floodplains and healthy riparian corridors has significantly decreased the availability of off-channel and in-stream habitats (Portland Multnomah Progress Board 2000).

Low flow conditions exacerbated by a loss of floodplain and wetland habitat, and an over-allocation of surface and groundwater to diversions, can negatively affect juvenile salmonids. Extremely low summer flows coincide with juvenile rearing times. This may force salmon into pools and intermittent tributaries that dry up and can ultimately strand them. (Portland Multnomah Progress Board 2000). Low creek flows may also cause stream temperatures to rise, negatively impacting salmonid spawning and rearing activities.

In addition to directly affecting salmon, altered stream flows can affect the aquatic insect and invertebrate community, the food source for salmonids. (See the Water Quality Chapter for more information on the aquatic invertebrate community of local streams).

Local Climate

The Salem-Keizer area has a modified marine climate (Schott and Lorenz 1999). Typical weather patterns originate in the Pacific Ocean and tend to move west to east across the region. As air masses move in the easterly direction, the Coast Range tends to modify temperatures and precipitation. The land elevations range between 150 feet (downtown Salem) to 1,093 feet (Eola Hills). Most of the higher elevations are located in the South Salem Hills and portions of West Salem. There is an elevated river terrace marking the edge of the modern floodplain (100 to 500 year recurrence intervals) of the Willamette River in the north end of Keizer (Schott and Lorenz 1999). The Willamette Valley floor is flat with slopes of three percent or less.

Annual average precipitation is about 41 inches, 90% of which falls between the months of October and the end of May. The monthly precipitation averages between six to seven inches from November through January. According to an Oregon State

University report, long-term wet-dry cycles are prevalent in the state of Oregon (Taylor 1999**).** These wet and dry "cycles" generally span 20-25 years. The report indicates that the dry years tend to be warm (most likely due to cloudiness) and the wet years cool. The dry (and warm) periods are estimated from about 1920-1945 and 1975-1994, with the wet periods taking place before and after (Taylor 1999). The data indicates that we may be entering another wet cycle. However, being in a wet cycle does not preclude the chance of having a dry year. This is evident when Oregon experienced a drought year in 2001. Salem recorded 21.97 in the 2001 water year. This is the second driest year on record for Salem. The record low for Salem is 20.37 set in 1976-77 (Oregon Climate Service 2001).

Typically, there are five or fewer days with snow cover each year. Average daily minimum temperatures range from 33 to 52 degrees Fahrenheit. Average maximum daily temperatures range from 46 to 82 degrees Fahrenheit. In July 1941 a historical high temperature of 108 degrees Fahrenheit was recorded. The high was met again in August 1981. On December 8, 1972, a historical low temperature measured minus 12 degrees Fahrenheit (City of Salem 2001c).

Concept Of Flood Frequency

Flood recurrence levels are the way to express the likelihood of a given flood event occurring in a given year. Flood frequency is based on historic records of flow at stream gauging stations. It is a measure of probability. There is a one percent statistical chance of having a 100-year flood each year. Over the course of 30 years (the average length of a residential loan), there is a 26% chance that there will be a 100-year flood. The severity of a flood depends on many factors, including the drainage area and its characteristics and antecedent moisture. Smaller streams are much more sensitive to short duration, high intensity rainfall than larger basins (City of Salem 1996).

Since Euro-American settlement, the Willamette River has experienced 10 major flood events (**Table 5-1**).

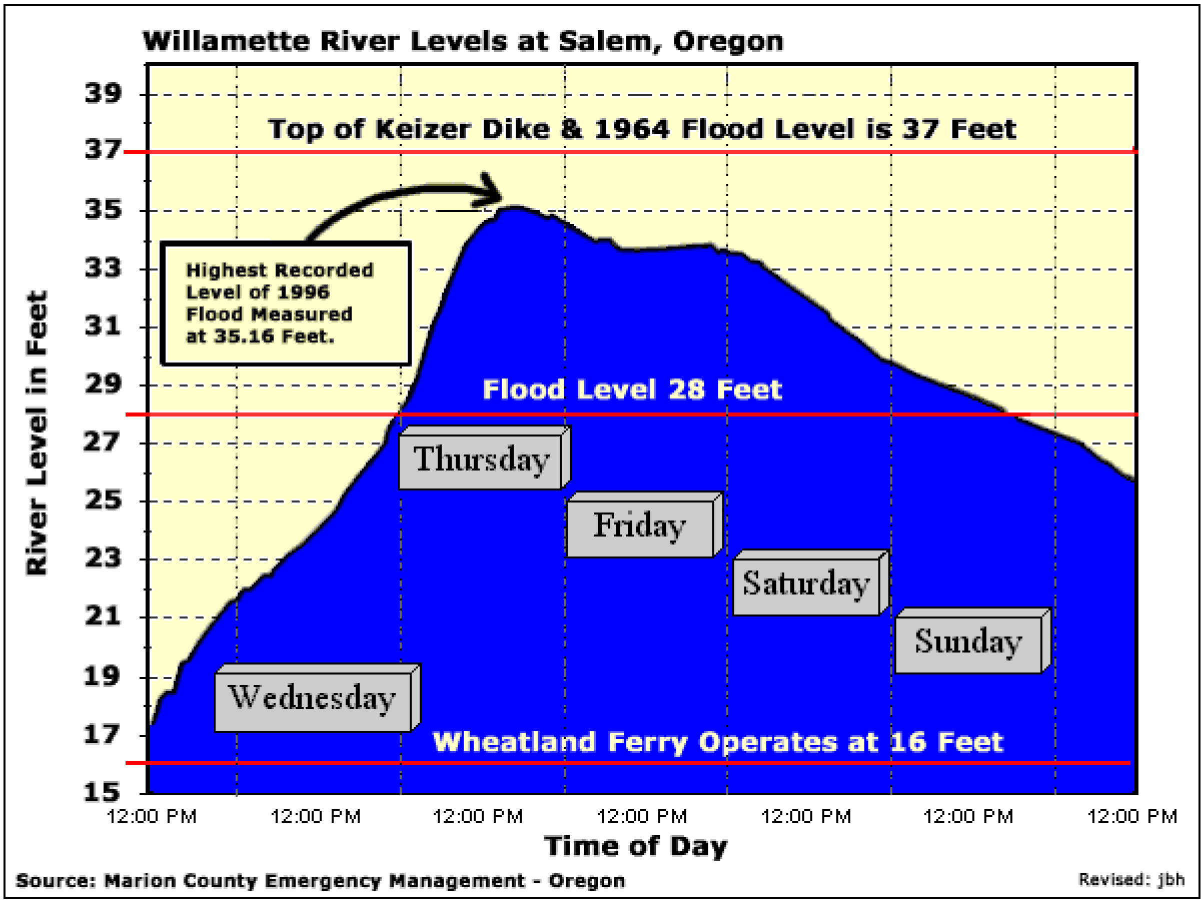
Table 5-1. Willamette River Flood Events at Salem.

Month/Year	Gauge Height	Discharge sec./ft.	Notes
Dec 1861	About 47′	500,000	Salem's great flood occurs, waters reach as far inland as the courthouse. Heavy snow falls on Salem in November and heavy rain in December, cresting the Willamette River at 47 feet in Salem.
Jan 1881	44.3′	428,000	-
Feb 1890	45.1′	448,000	-
Jan 1901	31.5′	329,000	-
Feb 1907	31.3′	325,000	-
Nov 1909	30.5′	315,000	Maximum discharge observed.
Jan 1923	38.3′	348,000	-
Jan 1943	38.6′	291,000	January floods after 60 days of rain and 26 inches of snow make the Marion Street bridge inaccessible. Willamette River crests at 38.6 feet.
Dec 1964	37.8′	308,000	The Salem area was flooded at Christmas time and described as one of the most significant and extensive Pacific Northwest flood events in recorded history. The Willamette River crests at 37.8 ft., caused by warm rain on top of snow and frozen ground.
Feb 1996	35.16′	244,000	On February 7, 1996, the Willamette River experienced a flood similar to the 1964 flood event; the storm occurred further north in the valley.

Source: USGS (1998); notes were compiled from City of Salem (2001c).

The 1996 flood was the most recent high water event experienced in the Salem area. A series of storms that extended from Hawaii to Oregon followed a week of extremely cold weather, which froze the already saturated ground. The winter of 1995-96 had already produced well above the average rainfall for the year, and many people experienced problems with high groundwater and runoff they had not seen before (City of Salem 1996). Flood level is 28 feet. The Willamette River reached well above flood level on February 7, 1996 (**Figure 5-2**). The rainfall that caused the flood of 1996 was the greatest three-day total for the period 1928 to 1996. For a more comprehensive documentation of the February 1996 flood and how it compares with previous floods in the Salem Area, please consult the Post Flood Report prepared by City of Salem Department of Public Works (City of Salem 1996).

Figure 5-2. Graph of daily flood levels of the Willamette River at Salem, February 1996.



Source: Salem Oregon Community Guide, **http://www.oregonlink.com/flooding/**

While the 1996 flood did cause property damage, it wasn't considered an extreme event in the history of the Willamette River (Corvallis Environmental Center 1998). Prior to the construction of dams in the mid 1900's, many larger floods have occurred as indicated in **Table 5-1**. Reservoirs and dams constructed in upper watersheds have limited the extent of flooding in the Willamette Valley. Flow has been regulated since 1941 by Fern Ridge Reservoir, 1942 by Cottage Grove Reservoir, 1949 by Dorena Reservoir, 1953 by Lookout Point and Detroit Reservoirs, 1961 by Hills Creek Reservoir, 1963 by Smith River Reservoir and Cougar Reservoir (Hadden pers. comm.). Although dams have successfully helped reduce flooding over the years, they have also presented major obstacles for safe juvenile fish passage and have limited accessibility to spawning habitats. At the time dams were constructed, it was not widely appreciated that flooding is a natural process that actually has many beneficial aspects for the river ecosystem. Flooding recycles nutrients through the floodplain, redistributes sediments, and recruits large woody debris into the stream that helps form habitat for salmonids. Floods flush sediment and re-create gravel bars, which are spawning habitat for salmonids and good substrate for some stream insects (Corvallis Environmental Center 1998).

Hydrologic Features of the Watersheds

Pringle Creek

Southeast Salem is drained by Pringle Creek. The Pringle Creek watershed is 13.3 square miles and is located almost entirely within the City of Salem's urban growth boundary. The basin terrain is moderate in slope, the topography consisting of flat lands and hillsides (City of Salem Public Works Department 2000). There are five main tributaries in the Pringle Creek system (City of Salem 2001b). These include Clark Creek, Pringle Creek, East Fork, Middle Fork and West Middle Fork. Mill Creek (which overflows during flood conditions to the East and Middle Forks of Pringle Creek) and Shelton Ditch (upstream of Pringle Creek's confluence with the Willamette) also contribute water to Pringle Creek during flood events (City of Salem Public Works Department 2000). Culverts under Liberty Road South at Skyline were doubled in size in 1999-2000, based in large part upon modeling done for the Stormwater Master Plan, to handle increased flow expected from future Skyline area development. During peak storm events, considerable water is stored in fields in the vicinity of the Salem Airport. A 1983 USGS study reports that some minor channel storage also occurs in the upper parts of the basin and is probably the result of man-made constrictions (Laenen 1983).

The Salem Local Wetland Inventory (Schott and Lorenz 1999) shows that wetlands are typically located along streams in the Pringle Creek watershed (**Map 5-1**). Larger areas of wetlands are located along the eastern portion of the watershed, where land use is primarily industrial.

The Pringle Creek watershed has suffered from the historical use of drainage tiles in the eastern portion of its watershed. Before the Fairview Industrial Complex was built, the land was once drained by a series of ditches and tile lines for farming purposes. Information regarding the location of these tiles lines was lost when the land was developed for industrial uses. The long-term consequence of these abandoned tile lines became evident when SumcoUSA spilled acid on its property in the April of 2000. The acid seeped into the ground and traveled along an abandoned tile line and directly into the creek. A fish kill was the result (see Fish and Wildlife Chapter for more details).

A map of the Pringle Creek watershed and its floodplain as determined by the Federal Emergency Management Agency (FEMA) has been included (**Map 5-2**). A comparison of the land use map (**Map 5-3**) with the FEMA map shows that both industrial and public land in the eastern portion of the watershed lie completely within the FEMA floodplain. High and low density residential development is located adjacent to the floodplain just south and west of Turner Road. Commercial and public land use practices are found along the northern borders of the FEMA floodplain. Most of the upper watershed is residential.

Pringle and Mill Creek have been channelized in numerous locations in the downtown area. According to Schott and Lorenz (1999), flooding is relatively infrequent in the lower reaches of these creeks with riparian wet spots restricted to undeveloped reaches, such as Pringle Creek through Bush Park. Historically, the area near Salem Hospital, Pringle Park and Bush's Pasture Park was subject to flooding. Pringle Hall, in Pringle Park, was destroyed in the 1996 flood. Residents of the watershed claim that the lower reaches of Pringle Creek now experience seasonal flooding, not infrequent flooding, as claimed by Schott and Lorenz (1999). Flooding has reached proportions in which streets have been impassible and, homes and businesses have incurred damage during seasonal flood events, such as businesses between 12th and 25th streets, and along Strong Road. Flooding also occurs higher up in the system, including Cannery Park and Idylwood Street near Woodmansee Park.

Glenn and Gibson Creeks

The Glenn-Gibson basin drains 10.4 square miles of West Salem, with approximately half of the watershed located within the urban growth boundary (City of Salem 2000). The basin terrain is steep, particularly in the upper reaches, with flatter slopes near the basin outlet. Creeks flow down steeper gradients than on the valley floor and stream channels tend to be narrow and generally lack broad floodplain or riparian areas (Schott and Lorenz 1999). The 1983 USGS study reports that the basin has a moderate amount of storage and that elimination of storage, by improving channels and draining topographic depressions, would increase peak flows approximately 70 percent (Laenen 1983). While over 20 small tributaries exist in the basin, Glenn and Gibson Creeks are considered the two main drainage channels for the watershed (City of Salem Public Works Department 2000).

Many wetlands identified in the local wetland inventory are associated with streams in the Glenn-Gibson watershed (**Map 5-4**). Due to the hilly nature of the landscape, only linear segments of wetlands are found adjacent to Glenn and Gibson Creeks. Land use adjacent to most segments of streams in this watershed are either single family or vacant residential (**Map 5-5**). A map of the Glenn-Gibson watershed and the floodplain as determined by the Federal Emergency Management Agency (FEMA) has been included (**Map 5-6**). Because of the steep terrain, the 100-year floodplain is restricted to a narrow band along Glenn and Gibson Creeks.

Claggett Creek

The Claggett Creek basin drains approximately 20 square miles in Marion County, including east Salem and the City of Keizer. The Upper Claggett Creek basin is located within the City of Salem's urban growth boundary and drains east Salem in the upper reaches of the watershed. The Lower Claggett Creek basin includes the lower reaches of the watershed in the City of Keizer and agricultural areas in the northern portion of the watershed. The basin slope of Lower Claggett Creek basin is very flat which contributes greatly to widespread ponding in streets, parking lots and yards, particularly in areas draining into dry wells (Keizer Service District 1982). Lower

Claggett Creek basin also includes Labish Ditch, a ditch that drains a portion of Lake Labish. Historically, Lake Labish was an old channel of the Willamette River (Orr et al. 1992). The area is now intensively farmed and drained by a network of ditches. Lake Labish drains in two directions, west to Claggett Creek and east into the Little Pudding River. During normal rain events the two watersheds remain distinct. However, during severe flood events such as occurred in December 1995, February 1996, and January 1997, the Pudding River backed up, contributing to headwater flooding of the ancient lake (Schott and Lorenz 1999). The use of tiles to drain agricultural areas has been extensive in the Claggett Creek basin, which affects both peak flow and runoff volumes in the watershed. According to a USGS study (Laenen 1983), runoff volume in Hawthorne Ditch and Claggett Creek were 100 percent and 180 percent higher, respectively, than predicted due to extensive tiling in east Salem. This would indicate that these two waterways are very "flashy" and experience intense short-duration high flows during and after precipitation events.

Locally identified wetlands are found along Claggett Creek (**Map 5-7**). The largest parcel of contiguous wetlands exists along Claggett Creek in the City of Keizer. Land use along this reach of the creek is a mix of public and residential (**Map 5-8**). The upper portion of the watershed is dominated by commercial, industrial and residential land uses.

A map of the Claggett Creek watershed and its floodplain as determined by the Federal Emergency Management Agency (FEMA) has been included (**Map 5-9**). The FEMA 100-year floodplain map indicates that the northwestern portion of the Claggett Creek watershed lies completely within the designated Willamette River floodplain. North of Chemawa Road and west of River Road, the land use practices are a mix of single and multi-family residential, public, commercial and agricultural.

Mill and Battle Creeks

The Mill Creek watershed is about 24 miles long and six miles wide and drains approximately 110 square miles. Headwaters of Mill Creek are located east of Salem, in the foothills of the Cascades. Within the City of Salem, the basin includes over ten miles of waterways draining an eight square mile area. Mill Creek has several natural and man-made tributaries. The three major tributaries are Beaver Creek, McKinney Creek, and Battle Creek. The Mill Race and Shelton Ditch are the two main channels of the Mill Creek system. Several smaller tributaries drain into Mill Creek, contributing some natural flow, but the main source of water for the creek during the summer is the North Santiam River. Water from the North Santiam is diverted into the Salem Ditch at Stayton. The Salem Ditch is approximately four miles long and flows west through Stayton, then heads northwest before flowing into Mill Creek west of Golf Club Road. The creek then flows mainly west through Aumsville and Turner. At Turner, Mill Creek begins to flow in a northwest direction. Mill Creek flows in a northwesterly direction through Salem until it empties into the Willamette River north of the intersection of D Street and Front Street.

The Mill Race, a man-made channel, was originally constructed in 1864 for power generation. Stream flow in the Mill Race is conveyed through a concrete-lined sluice (Schott and Lorenz 1999). Portions of the Mill Race consist of open channels, as in the segment that flows through Willamette University. The "headworks" are located at 20th and Ferry S.E. (at Mill Race Park, across from a small restaurant). The inlet control structure has three adjustable slide gates which are controlled by the City of Salem's Parks Operations, and are kept locked at all times. There is a siphon inlet at the downstream western end of Willamette University that feeds the "waterway"/water feature through Pringle Plaza. This waterway also feeds the Civic Center's mirror pond via a gravity pipeline across Pringle Creek behind the Main Fire Station (Downs pers. comm.).

A portion of Mill Creek is diverted into Shelton Ditch just east of Airport Road. Shelton Ditch is used by Salem as an overflow for flood control (City of Salem 2001b). Following an earlier natural stream course, Shelton Ditch was constructed as a drainage channel in the mid 1930's to help relieve flooding in the lower reaches of Mill Creek. In 1984, the section of Shelton Ditch between Winter and Church Street was re-developed in part to provide for an urban pedestrian walkway. (See Historical Conditions chapter for further information).

According to Salem's Stormwater Master Plan, drainage improvements for the Mill Creek basin will need to be compatible with efforts to protect native fish runs (City of Salem Public Works Department 2000). The U.S. Army Corps of Engineers (COE) recently studied potential flood reduction within the system, and it was hoped that the study would identify several potential flood mitigation projects for future implementation (City of Salem Public Works Department 2000). However, no potential improvements met the COE's minimum cost benefit ratio.

Battle Creek basin drains approximately 10 square miles. Slightly less than half of the basin lies within Salem's urban growth boundary. The creek flows southeast out of Salem over steep terrain. The five main tributaries to Battle Creek include, Jory Creek, Powell Creek, Waln Creek, Scotch Creek, and Cinnamon Creek (City of Salem Public Works Department 2000). The 1850 General Land Office survey indicated a sizeable wetland at the confluence of Waln and Battle Creeks. The basin had considerable storage, which should be expected in a primarily rural basin. The elimination of this storage would increase peak flows an average of 150 percent by model estimate (Laenen 1983). According to the 1983 USGS report, the impervious area of the Waln Creek basin nearly doubled from 1938 to 1980. Since 1983, growth has exploded throughout the basin, with numerous completed subdivisions. Waln Creek is also rare in having an undeveloped riparian corridor in its midsection, which serves to lessen water movement, thus decreasing peak flows (Laenen 1983).

Locally identified wetlands are found along certain reaches of Mill Creek (**Map 5-10**). The 1999 Local Wetland Inventory (LWI) did not identify any riparian wetlands along the reach of Mill Creek located on State penitentiary farm property. Several isolated farmed wetlands are located on the southeast portion of the farm property. Between Kuebler Blvd. and Hwy. 22, including Cascade Gateway Park, there are several ponds created by gravel mining (Schott and Lorenz 1999). The LWI also indicates that the best examples, in terms of diversity of native plant species, of wet prairie and forested wetlands are found in wetlands adjacent to or near the banks of Mill Creek between Highway 22 and the Southern Pacific Railroad. Currently, there are no native wetlands in the downtown Salem area (Schott and Lorenz 1999); however, there are historical accounts of wetlands in this location (see History Chapter and Riparian/Wetlands Chapter). **Map 5-11** depicts wetland areas found in Battle Creek basin. The Salem-Keizer LWI identifies several wetland and wetland mitigation projects along Battle Creek (Schott and Lorenz 1999).

Map 5-12 and **Map 5-13** show the extent of the 100-year floodplain in the Mill Creek watershed both in the City of Salem and in the rural portions of the watershed. Within Salem's UGB, the 100-year floodplain consists of primarily industrial and public development. Some areas of commercial and multi-family residential development are also found within the floodplain. Outside of Salem's UGB, mostly agricultural and residential agricultural land uses are found within the 100-year floodplain. Parts of Turner, Aumsville and Stayton, small cities within the watershed, have also been mapped within the 100-year floodplain.

Effects of Land Use on Hydrology

Alteration to the natural landscape changes the way water travels across the land, how the land retains the water, and how it empties into a stream. Such flow alterations are driven primarily by changes in type and density of vegetation and by infiltration rates. These changes can affect the magnitude, duration and impact of floods. An increase in the amount of impervious surface (e.g., removing natural vegetation and replacing it with rooftops and transportation networks) and channel modifications (e.g., filling wetlands associated with a stream, channelization, rip-rapping stream banks, placing streams in closed pipes) are examples of how human activities have decreased infiltration rates of precipitation and impacted the flow of water across the landscape. The result of channel modifications and an increase in impervious surfaces in a watershed is an increase in peak discharge for the receiving stream. A stream responds to increased flows by expanding its width or by cutting deeper into its streambed. These responses in turn contribute to channel instability, stream bank erosion, and habitat degradation. In the Pacific Northwest, the combined effect of increased precipitation in the winter and the modifications to drainage patterns listed above, create stream flows often described as "flashy." A stream experiencing "flashy" stream flow will typically move large volumes of water for a short duration immediately during and after a precipitation event. Due to decreased infiltration rates of the precipitation, the same stream may experience none to very low flows between precipitation events.

Impervious Surfaces

According to Schueler (1994), the definition of "impervious surface" is the sum of roads, parking lots, sidewalks, rooftops and other impermeable surfaces of the urban landscape. Other impermeable surfaces would include compacted soils and semi-impermeable lawns. During each stage of land development, this variable can be easily quantified, managed, and controlled, which makes it a valuable tool to measure the extent of urbanization. Many past scientific studies have related imperviousness to specific changes in hydrology, water quality, and the habitat structure and biodiversity of streams.

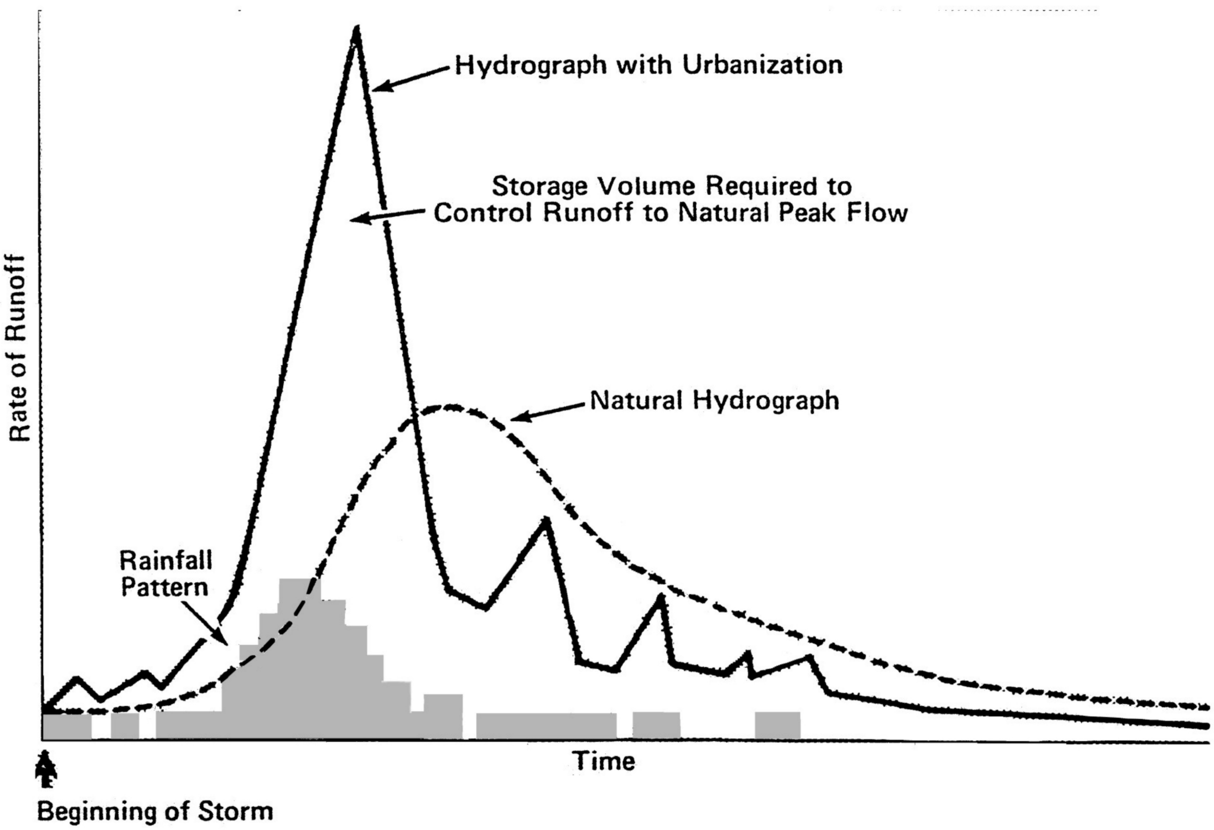
Hydrology

Without stormwater detention, urbanization, as reflected by downstream flood hydrographs, causes higher flood peaks and impacts to fish habitat as well as increases the risk of flood damage to property (City of Salem Public Works Department 2000). **Figure 5-3** shows the standard urban hydrograph that can be applied to any urbanizing area. (Warren 1978). The change caused by urbanization from a rural basin to a fully developed basin will increase peak discharge more than three-fold and storm runoff by two-fold. (Laenen 1983). However, a model relating stormwater runoff and urbanization in the Willamette Valley (Laenen 1983) shows that storage of stormwater can reduce peak flows. According to USGS calculations, if one percent of the land in a watershed is used for stormwater storage, peak discharge may be reduced by approximately 40 percent.

According to Salem's tree canopy analysis," communities that use increased tree cover to help manage stormwater can reduce the cost of constructing stormwater infrastructure" (City of Salem 2001a). This is because trees and soil both retain water and so reduce runoff. Salem's average canopy cover in 2001 within the urban growth boundary was 17.54%, well below the suggested standard of 40% tree cover. Even with that, however, the one-time value of existing tree canopy benefits for Salem were estimated to be in excess of $148 million. Its annual benefit to stormwater management is estimated at almost $965,000 (City of Salem 2001a).

For streams with high restoration potential, stream restoration and/or increasing channel capacity (e.g. laying back banks, creating wetland benches in stream channels) can be used to mitigate for higher than normal rates of channel erosion/scouring and riparian damage associated with high flows. The City of Salem's Stormwater Master Plan (City of Salem Public Works Department 2000) outlines how development policies, attenuation (detention) facilities, and channel alterations can mitigate the impacts of high flows. Details on stormwater management for the Pringle, Glenn-Gibson, Claggett, and Mill Creek watersheds will be provided at the end of this chapter. For additional information, please consult the City of Salem's Stormwater Master Plan.

Figure 5-3. A Typical Urban Hydrograph



Source: Urban Land Institute – Environmental Comment. Adapted from the article *Drainage as a Municipal Utility* (Warren 1978).

Water Quality

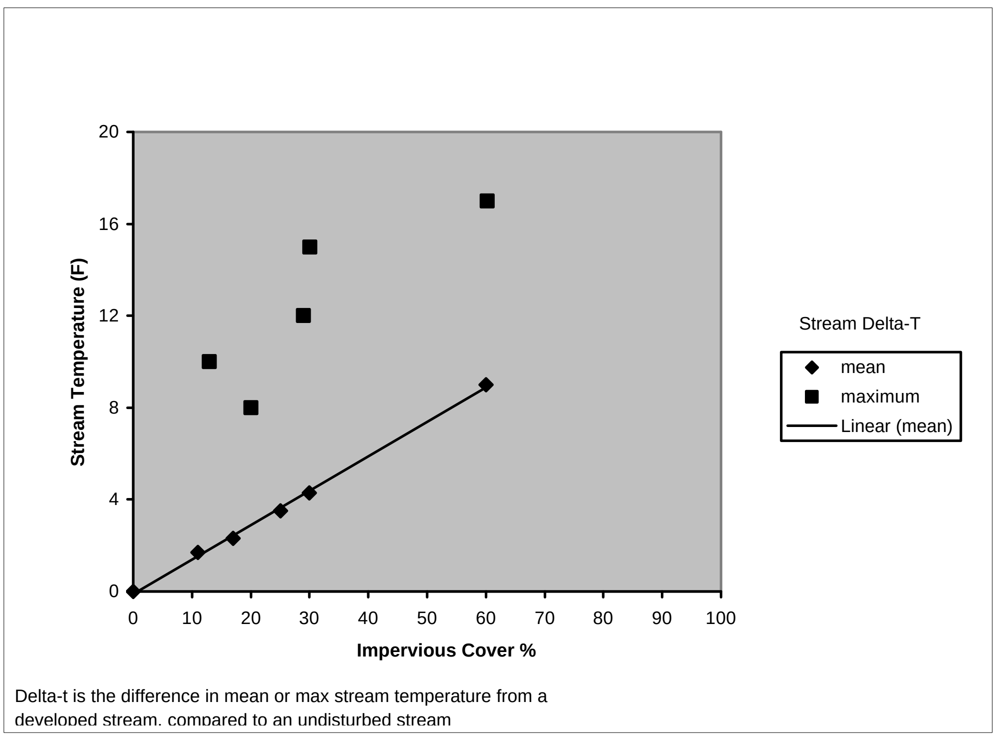
During storm events surface runoff from impervious areas is quickly washed into streams either directly or via stormwater systems. Monitoring and modeling studies have consistently indicated that urban pollutant loads are directly related to watershed imperviousness (Schueler 1994).

The best way to reduce the amount of pollutants in a stream is to prevent the pollutants from entering the stream in the first place. Best Management Practices (BMPs) include structural or nonstructural devices designed to temporarily store or treat stormwater runoff in order to mitigate flooding, reduce pollution and provide other amenities that help prevent pollutant runoff. Some BMPs already implemented by the City of Salem include practices such as educating the public on improving water quality through small everyday changes in behavior (e.g. the Watershed Enhancement Team Program), and a new erosion control ordinance and riparian buffer ordinance. City staff is drafting standards, criteria and policies for construction of parking lot bioswales. The City of Salem is also planning to expand regional stormwater detention facilities (City of Salem Public Works Department 2000). BMPs for Marion County have recently been outlined in the *Marion County Salmon Recovery Plan* (Marion County Public Works Department 2001). The areas to be focused on include, vegetation management, ferry maintenance and operations, maintenance of bridges, fleets, and parks as well as service districts and engineering designs (Marion County Public Works 2001).

Further study is needed to assess which pollutant loads (i.e., phosphorus, nitrogen, etc.) can be reduced when BMPs are implemented. Depending on the practice selected, past monitoring studies of phosphorus loads showed decreases of 40 to 60% (Schueler 1994). Please refer to the Water Quality chapter of the assessment for additional details on what types of pollutants are found in the watershed.

Increases in urban stream temperatures in summer appear to be directly related to the amount of impervious cover found in a watershed (**Figure 5-4**) (Galli 1991). Galli (1991) also reports that other factors, such as lack of riparian cover and in-stream ponds, amplify stream warming, but the primary contributing factor still appeared to be the amount of impervious cover in the watershed.

Figure 5-4. The Effect of Impervious Cover on Stream Temperatures



Source: Center for Watershed Protection (1998).

Habitat Structure and Aquatic Biodiversity

Changes in the hydrologic regime, channel morphology and water quality of an urban stream impact habitat structure. Changes in habitat structure ultimately lead to changes in the aquatic community. Research conducted in many regions and using different methods has concluded, "stream degradation occurs at relatively low levels of imperviousness (~10%)" (Schueler 1994). Research performed on stream quality in the Pacific Northwest demonstrates how aquatic communities are adversely impacted by urbanization (**Table 5-2**).

Table 5-2. Review of Key Findings of Urban Stream Studies Examining the Relationship of Urbanization to Stream Quality in Seattle, Washington.

Researcher(s)	Year	Location	Biological Parameter	Key Finding
Booth	1991	Seattle	Fish habitat and channel stability	Channel stability and fish habitat quality declined rapidly above 10% imperviousness.
Luchetti and Fuersteburg	1993	Seattle	Fish	Marked shift from less tolerant Coho salmon* to more tolerant cutthroat populations noted at 10-15% imperviousness at nine sites.
Pedersen and Perkins	1986	Seattle	Aquatic insects	Shifted to chironomids (midges and mosquitoes), olgliochaetes (aquatic worms) and amphipods (scuds) species tolerant of unstable conditions.
Steward	1983	Seattle	Salmon	Marked reduction in Coho salmon populations noted at 10-15% imperviousness at nine sites.
Taylor	1993	Seattle	Wetland plants/ amphibians	Mean annual water fluctuation was inversely correlated to plant and amphibian density in urban wetlands. Sharp declines noted above 10% imperviousness.

* Coho salmon have not been documented in the Salem area watersheds.
Source: Adapted from Center for Watershed Protection (1998).

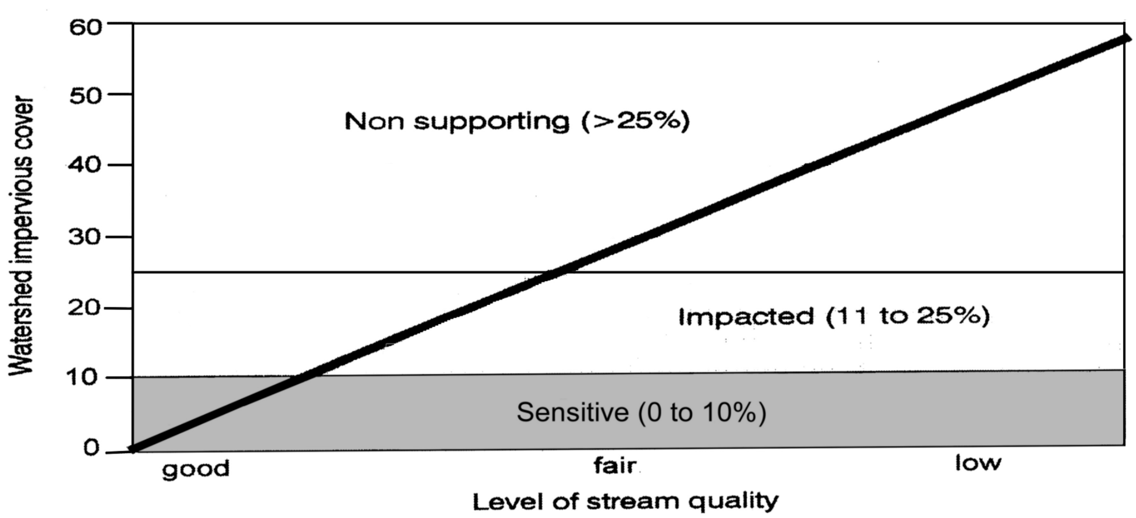
In addition to the studies mentioned in **Table 5-2**, a 1979 macroinvertebrate study conducted by the American Water Resources Association reveals that biodiversity in urban streams drops rapidly when imperviousness exceeds 10 to 15% (Klein 1979). Species more tolerant of pollution and hydrologic stress such as chironomids, tubificid worms, amphipods, and snails replaced resident species such as stoneflies, mayflies, and caddisflies. (Please refer to the Water Quality Chapter for additional information on stream macroinvertebrates).

After reviewing many articles relating stream health to impervious cover, Schueler (1994) suggests the following classification of streams based on percent impervious area in a watershed:

1. Sensitive streams (one to 10 % impervious cover)
2. Impacted streams (11 to 25% impervious cover)
3. Non-supporting streams (26-100% impervious cover)

A graphic representation of this index is shown in **Figure 5-6.** The resource objective and management strategies in each stream category differ to reflect the potential stream quality that can be achieved (Schueler 1994). The most protective category is "sensitive streams" where steps should be taken to preserve pre-development stream quality. "Impacted streams" are above the 10% threshold and can be expected to experience some degradation after development (i.e., less stable channels and some loss of aquatic diversity). The key resource objective for these streams would be to mitigate impacts to the greatest extent possible, using effective stormwater management practices. The last category, "non-supporting streams" recognizes that predevelopment channel stability and biodiversity cannot be fully maintained, even when stormwater practices or retrofits are applied. The biological quality of non-supporting streams is generally considered poor, and is dominated by insects and fish that are tolerant of pollution (Center for Watershed Protection 1998). The primary resource objective for "non-supporting" streams shifts to the protection of water quality downstream by removing urban pollutants. However, efforts to protect or restore biological diversity are not abandoned. In some subwatersheds intensive stream restoration techniques can be employed to attempt to partially restore some aspects of stream quality.

Figure 5-6. Impervious Cover vs. Stream Quality for Sensitive, Impacted and Non-Supporting Streams.



Source: Center for Watershed Protection (1998)

Impacts of Urbanization on Watersheds

Using the index provided by Schueler (1994), we attempted to determine the health of our streams by calculating the amount of impervious cover per watershed. Land use classification data was used to estimate the impervious area within each watershed (**Table 5-3**).

Table 5-3. Impervious Area Percentages Used to Calculate Total Impervious Area for Salem-Keizer's Watersheds.

Percent Impervious by Land Use		
Land Use	**Percentages in Salem SWMP[1]**	**Revised Percentages (%)[2]**
Single Family Residential	50	50
Medium Density Residential	60	
High Density Residential	75	
Multi-Family Residential	- -	67 [3]
Commercial	90	90
Industrial	90	90
Agricultural	Existing Imp. Area Used	2 [4]
Public (parks, schools, gov. offices)	Evaluated Individually	25[4]
Residential Ag/Urban Transitional	25-50	8 [5]
Parking Lots	- -	100[6]

[1] These impervious area percentages were used to calculate total impervious area in Pringle, Glenn-Gibson watersheds, and the portion of the Mill Creek watershed within the Salem UGB only.

[2] These revised impervious area percentages were used to determine total impervious area for the Claggett Creek and Mill Creek watersheds. Revised percentages were used due to time limitations and mapping constraints.

[3] This percentage is the average of the Med-Density and High-Density percentages.

[4] These estimated percentages were used by reviewing existing percent impervious areas for catchment basins as presented in the Model Development and Methods section for the SWMP (City of Salem 2000).

[5] Figure for Residential Agriculture was taken from the Marion County Public Works zoning data and is based on a 5000 square foot area and a minimum lot size of 1.5 acres as suggested by Lisa Milliman, an Associate Planner with Marion County. Urban Transitional was also given the same estimate of percent impervious.

[6] We estimated parking lot coverage to be 100% impervious.

The impervious cover percentage for an entire watershed is calculated by multiplying the percent impervious for a land use category with the total acreage of that land use in the watershed. The total impervious area for each land use in the watershed is then added up and divided by the total area of the watershed, as displayed in this equation: Watershed Impervious Cover (%) = Total Impervious Area / Total Area.

The Salem Futures criterion on impervious surface shows 55% of the already-developed acres in Salem as being impervious surface. 42% of the land inside the urban growth boundary is covered by impervious surface today (Parsons Brinckerhoff 2001). Impervious coverage was determined by the City of Salem for Pringle and Glenn-Gibson watersheds.

Since land use inventory data was not available for the Mill Creek watershed outside Salem's urban growth boundary, zoning data was used. According to Marion County staff, the county zoning data closely resembles actual land use (Milliman pers. comm.). Zoning information was used in the same manner as land use data to determine impervious cover.

Both existing impervious cover and future impervious cover, assuming maximum build-out, were calculated for some watersheds (**Table 5-4**). Maximum build-out calculations are estimates of the percent of impervious cover that would result if all land was developed as planned. This estimate was calculated by assuming that all land currently vacant (i.e., vacant residential, vacant industrial, vacant commercial) was developed. Vacant residential land was categorized into single family residential even though the type of residential development on any single piece of property is unknown at this time.

Table 5-4. Percent Impervious Surfaces by Watershed

	Total		Within Salem UGB Only	
Watershed	**Existing**	**Future**	**Existing**	**Future**
Pringle Creek	22.3%	51.6%	23.8%	51.7%
Glenn-Gibson	7.8%	25.5%	15.1%	43.7%
Claggett Creek	Not available	35.9%	Not available	Not available
Mill Creek	Not available	8.2%	26.6 %	49.2%[1]

[1] Includes portion of Battle Creek Basin within UGB.
Source: Adapted from City of Salem Public Works Department (2000).

Diagnosis of Stream Health for Each Watershed

The Pringle Creek basin contains a variety of land uses ranging from the central business district of Salem to single family residential and agriculture (**Map 5-3**). Most of the basin is developed. The southern portion of the basin contains currently undeveloped areas, which are zoned for industrial, commercial, and residential uses (City of Salem Public Works Department 2000). Bush's Pasture Park, a 100-acre community park adjacent to Willamette University, is the largest area of parkland/open space in downtown Salem (Schott and Lorenz 1999). With 22% existing impervious cover within the watershed, Pringle Creek ranks as an "impacted stream" according to the index proposed by Schueler (1994). Future development will easily push this stream into the "non-supporting" category.

Land use in the Glenn-Gibson basin is primarily single-family residential, vacant residential and general farm development (**Map 5-5**). The Glenn-Gibson basin is experiencing rapid growth in the upper-western reaches inside the urban growth boundary (City of Salem Public Works Department 2000). Rapid growth in Polk County, the rural portion of the watershed outside of the UGB, is also projected to occur within the next forty years (U.S. Bureau of Reclamation 1996). Existing impervious cover for the watershed is only 7%, which rates the creeks as "sensitive streams". The percent of impervious cover in the Glenn-Gibson watershed that lies within the Salem UGB is 15%. If land is developed as proposed by the City of Salem's land use inventory, the amount of impervious cover within the UGB will increase by almost three-fold. With maximum build-out, Glenn-Gibson watershed will reach 25.5% of impervious cover, thus changing the rating of the stream from "sensitive" to "non-supporting."

The Claggett Creek basin is highly developed. Land use includes single and multi-family residential, industrial, commercial and agricultural areas (City of Salem Public Works Department 2000) (**Map 5-8**). Undeveloped areas in the northeastern portion of the watershed are primarily in agricultural production growing a variety of crops including vegetables, grass seed, nursery stock, fruit and nut orchards (Schott and Lorenz 1999). No calculation was determined for existing impervious cover for the Claggett Creek watershed. However, the City of Salem did calculate percent impervious cover for the Upper Claggett Creek basin. This basin is found in the eastern portion of the watershed and contains a high proportion of commercial and industrial land uses. The western boundary of this basin is defined by the Salem Parkway and Portland Road (see City of Salem Stormwater Master Plan). The basin makes up approximately 33% of the entire watershed. Existing impervious coverage is estimated at 41.63% for the Upper Claggett Creek basin. Future impervious cover for this basin is calculated at 64.71%. Our estimate of future impervious cover for the entire watershed, assuming maximum build-out, is 35.9%. The existing impervious cover of the upper basin and the estimated future impervious cover of the whole watershed imply that Claggett Creek is a "non-supporting" stream.

Within the Salem urban growth boundary, the Mill Creek basin includes residential, commercial and industrial land uses (**Map 5-14**). Land use within the basin upstream of Salem is primarily agricultural (**Map 5-15**). Growth in the Mill Creek basin is occurring rapidly, particularly in the towns of Stayton, Aumsville, Sublimity, and Turner (City of Salem Public Works Department 2000). The city of Salem's Stormwater Master Plan indicates that stormwater flows from the above listed towns, including the Battle Creek basin, and empty into Mill Creek. Aumsville also seasonally discharges treated wastewater into Mill Creek waters (City of Salem Public Works Department 2000). A few large parcels of vacant land in the watershed are targeted for development. One area currently being considered for sale and development is land owned by the State of Oregon Department of Corrections. It is currently designated as public land on the City of Salem's land use inventory and is located in the southeast part of Salem. This land may eventually be converted into an industrial park.

According to our calculations, the portion of the Mill Creek watershed, including the Battle Creek basin, which lies within the Salem UGB will have a future impervious cover of 49.2%. Because most of the watershed is dominated by agricultural uses, maximum build-out will result in a total of just 8.2% impervious cover in the watershed. While the lower portion of Mill Creek will be impacted by urbanization, Mill Creek will still rank as a "sensitive stream".

In summary, streams can be classified into one of three categories based on the relationship between amount of impervious surface in a watershed and stream health. The categories are: sensitive, impacted, and non-supporting. Often, the most sensitive fish and aquatic insects disappear from impacted streams. Once watershed impervious cover exceeds 25%, waterways are typically categorized as non-supporting streams. Calculations for existing and future impervious cover indicate that Pringle, Glenn-Gibson, and Claggett Creeks are already or may in the future become non-supporting streams. Because land use is dominated by agriculture in the Mill Creek watershed, Mill Creek is and will remain a "sensitive stream" if current land use designations remain unchanged.

Effects of Water Use on Hydrology

The use of water for drinking, irrigation, industry, commercial and other activities competes with the needs of salmonids and the aquatic community. Each of the four watersheds diverts both surface and ground water for human uses. How much impact these water diversions are having on the aquatic community is not known. This section of the Hydrology Chapter will attempt to identify water users in the four watersheds. As will become evident later in this chapter, much work needs to be done to answer our questions on the affects of water use on salmonids in our local streams.

The majority of salmonid activity occurs during the fall, winter and spring when urban channels typically carry a large volume of stormwater (Galovich pers. comm.). During the summer months, most streams have reduced flow and higher temperatures. Higher stream temperatures in the summer months can restrict many species of fish to isolated stream reaches. How much of the flow and temperature change is "natural" (i.e. due to small, low elevation stream basins) and how much is due to human landscape alterations can be difficult to assess. However, historical data indicate more area springs and wetlands, as well as more gallery forest cover along streams. This, combined with less impervious surface, would have resulted in higher summer flows and lower summer temperatures.

Currently, Claggett Creek is believed to be warm throughout its entire reach during summer months. The same applies to the lower reaches of Glenn/Gibson and Pringle Creeks. The upper reaches of these latter two streams typically have enough flow to at least sustain fish (particularly cutthroat) throughout the summer months. The difference between Claggett Creek and the other two creeks' ability to maintain sufficient flow for fish may be due to the presence of groundwater resources such as springs in the upper reaches of the latter two creeks (Galovich pers. comm.). In some places, tributaries and upper reaches are placed into pipes, as Clark Creek is from South Salem High School until it joins Pringle Creek in Bush's Pasture Park. The result was a 10-degree reduction in temperature from point of entry to the point of discharge (Andrus 2000).

Flows through Mill Creek basin are incredibly complex and involve several upstream diversions for irrigation and industry (City of Salem Public Works Department 2000). Currently, the Santiam Water Control District actively monitors the water levels and flows in the Salem Ditch, which diverts water from the North Santiam River into Mill Creek. The district diverts up to 180 cubic feet per second (cfs) and utilizes about 90 miles of canals to service 17,000 acres of farmland west of Stayton (MWVCOG 2000). The Santiam Water Control District estimates that 130-150 cfs are added to natural flows in Mill Creek from June through September. The Perrin Lateral Canal and Mill Creek carry diverted water through the city of Turner and into Salem. The City of Salem manages the water level and flows for the Mill Race and Shelton Ditch within the confines of their water rights.

Water Rights and Water Use

Under Oregon Law the beneficial uses of water include: Agricultural and Land Management, Industrial/Commercial Uses, Drinking Water Supply, Community Water Supply and Environmental benefits (**Table 5-5**).

Table 5-5. Beneficial Uses of Water Under Oregon Law

Agricultural and Land Management	Industrial/ Commercial Uses	Drinking Water Supply	Community Water Supply	Environmental Benefits
Gen. Agricultural uses Irrigation Cranberry use Nursery operations Stockwater Temperature control Forest and range management	Industrial Commercial Fire protection Mining Power development	Human consumption Domestic use Domestic use expanded (for watering up to ½ an acre of lawn or noncommercial garden)	Municipal Quasi-municipal Group domestic Storm water management.	Aquatic life Pollution abatement Recreation Wetland enhancement Wildlife

Source: Oregon Water Resources Department (1997).

The Oregon Water Resources Department (OWRD) is the state agency charged with the administration of laws governing surface and groundwater resources. All water in Oregon belongs to the public, thus before any surface or groundwater can be used, a water right must be obtained. Cities, farmers, factory owners and other water users must obtain a permit or water right from the Water Resources Department to use water from any source (OWRD 1997). Since 1909, the Appropriation Doctrine has been in effect, which essentially means that the first person to obtain a water right on a stream is the last to be shut off in times of low streamflows. This person is called the "senior user," and the "junior users" are described as having been issued a more recent-priority water right. Information on how water rights are determined and the application process is available at the Oregon Water Resource Department.

If the "water rights" come into conflict (i.e., the rights have the same day of priority) then Oregon law states that domestic use and livestock watering have preference over all other uses. If a drought is declared by the Governor, OWRD can give preference to stock watering and household consumption purposes, regardless of the priority dates of the other users (OWRD 1997). Oregon water laws include some exempt uses of both surface and groundwater (**Table 5-6**). An exempt use does not need a water right. The water user can use as much water as desired, unless local ordinances provide further restrictions.

Table 5-6. Exempt Uses of Water Under Oregon Law

Surface water exempt uses	Groundwater exempt uses
Natural springs (collection and use)	Stock watering
Stock watering directly from source	Lawn or non-commercial garden watering
Salmon (raising salmon, fishways, etc)	Single or group domestic purposes
Fire control	Single industrial or commercial purposes
Forest management	Down-hole heat exchange uses
Land management practices (where water use is not the primary intended activity)	Watering (the grounds, ten acres or less, of schools located within a critical groundwater area)
Rainwater (collection and use)	

Source: Oregon Water Resources Department (1997)

The proper management of water use requires the combined effort of state, county and municipal officials and private landowners. For example, ODFW's role is to manage the protection of fish and wildlife (i.e., construction of effective fish ladders and fish screens), while the Oregon Water Resource Department's duty is to enforce water rights within the watershed. The permit holders (i.e., local water control districts, municipalities, private landowners) are responsible for operating within the limits of their water rights. They manage the day-to-day use of their water without close oversight by OWRD.

As more people move to the Willamette Basin, the major water uses (agriculture, industry, and municipalities), are likely to take even more water (Willamette Restoration Initiative 1999). A majority of the basin's water supply is allocated for out-of-stream uses (e.g., irrigation and drinking water) and subsequently competes with in-stream uses, such as fish protection, pollution abatement, and recreational opportunities. Competition between the existing water uses will continue to intensify as the seasonal water demands exceed the water supply.

To understand how water resources are used in our watersheds, one needs to look at both the distribution of water users and the type of water use. The terms Point of Diversion (POD) and Place of Use (POU) are explained below as they relate to the following discussion and interpretation of **Tables 5-7 and 5-8** and **Maps 5-16** through **5-19**:

Point of Diversion (POD): Each point on the map represents a surface or ground location where water is diverted (i.e., pump station, well, reservoir) for use by the water right holder under the terms of their water right. More than one point may appear at a given location on the map for each water right served by that particular POD. In other words, the same point of diversion may serve two different water uses, such as irrigation and livestock watering.

Place of Use (POU): Places of Use are areas, usually fields, where water is applied under the terms of the water right. They are represented by polygons on the map. The polygons can overlap one another, as in the case of one water right being supplemental to another for the same piece of land.

One Place of Use (POU) can be served by several Points of Diversion (POD). For example, a farmer may divert water from both a creek and a groundwater well to irrigate the same field. Rates of diversion are measured in either cubic feet per second (cfs) or in acre-feet (af). Cubic feet per second is a measurement of an instantaneous rate. Acre-feet is a measurement of volume that is used for PODs that are reservoirs.

Summary of Permitted Water Use by Watershed

Determining if water rights are over-allocated based on streamflow can be accomplished through hydrologic modeling. No such modeling has been done to determine if water rights are over-allocated in any of the four watersheds. For small watersheds such as these four, an accurate model is costly and requires a significant amount of time to process the data. OWRD's current policy is not to issue any new water rights in the summer months for these watersheds. It does issue new water rights for other times of the year.

Water rights information was obtained from the OWRD web page, using the Water Rights Information System (WRIS) (OWRD 1997). Unfortunately, the water rights database has not been thoroughly updated. All current users are in the database, but so are all historic users, who may or may not be using their water rights. Water rights no longer being used have not been purged from the system. For this reason, an accurate measurement of water currently being diverted from a watershed is unknown.

To get a general idea on how water is allocated in the four watersheds, we summarized all the water rights records in the WRIS database (**Table 5-7**). The information provided in **Table 5-7** and **Map 5-16** through **Map 5-20** represents all historic and current records of permitted water rights in the four watersheds. Many of the water rights may not be in use today.

Table 5-7. Number of Current (2001) and Historic Water Allocations by Water Use Type

	Pringle Creek Watershed		**Glenn Gibson Watershed**		**Claggett Creek Watershed**		**Mill Creek Watershed**	
Water Use Type	**#POU[1]**	**%POU[2]**	**#POU**	**%POU**	**#POU**	**%POU**	**#POU**	**%POU**
Agriculture								
Agriculture	?	?	3	2.9	2	0.6	2	0.5
Nursery Use	2	2.4	?	?	6	1.9	2	0.5
Domestic								
Domestic – Inc lawn and garden	5	6.0	3	2.9	2	0.6	7	1.9
Domestic	1	1.2	8	7.8	16	4.9	21	5.8
Stock	2	2.4	3	2.9	?	?	15	4.1
Group Domestic	?	?	2	2.0	1	0.3	?	?
Industrial								
Commercial	?	?	1	1.0	2	0.6	?	?
Manufacturing	10	11.9	--	--	8	2.5	4	1.1
Municipal								
Municipal	4	4.8	?	?	2	0.6	? [2]	?
Quasi-Municipal	?	?	1	1.0	5	1.5	?	?
Irrigation								
Irrigation	41	**48.8**	46	**45.1**	260	**80.2**	219	**60.0**
Irrigation & Domestic	4	4.8	3	2.9	6	1.9	2	0.5
Irrigation and Stock	?	?	1	1.0	?	?	3	0.8
Supplemental	1	1.2	5	4.9	5	1.5	19	5.2
Miscellaneous								
Air Conditioning	1	1.2	--	--	3	0.9	1	0.3
Aesthetic	2	2.4	?	?	?	?	?	?
Fire Protection	?	?	?	?	3	0.9	?	?
Storage	1	1.2	17	16.7	1	0.3	14	3.8
Aquaculture	?	?	?	?	--	--	1	0.3
Recreation								
Recreation	1	1.2	6	5.9	1	0.3	10	2.7
Power								
Power	3	3.6	?	?	1	0.3	3	0.8
Livestock								
Livestock	1	1.2	1	1.0	?	?	28	7.7
Fish								
Fish	5	6.0	1	1.0	?	?	12	3.3
Wildlife								
Wildlife	?	?	1	1.0	?	?	2	0.5
TOTAL	**84**	100	**102**	100	**324**	100	**365**	100

[1] POU refers to Place Of Use.

[2] %POU is a percent of the total number of POUs that fall into a type of water use. It is NOT the percent of the actual amount of water being used for that type of water use.

Source: Oregon Water Resources Department (2001)

Irrigation is an important use of water in the Pringle, Glenn-Gibson, Claggett, and Mill Creek watersheds. Water is made available for irrigation purposes in the Pringle, Glenn- Gibson, and Claggett Creek basins from March 1– October 31, and from May 1 - September 30 for the Mill Creek basin (Ferber pers. comm.).

The following maps show the locations of water diversions and indicate the water use. The maps identify both current and historic points of diversion.

Pringle Creek

Map 5-16 shows the types of water uses at different points of diversion (POD) in the Pringle Creek watershed. A majority of the diversions is groundwater wells. Diversion rates range from 0.0025 - 44.50 cfs. The map indicates that reservoirs are used for agriculture, fish, recreation and miscellaneous uses. Reservoirs store water at volumes between 1.0-44.5 acre-feet.

Glenn-Gibson Creeks

Map 5-17 shows the types of water uses at different points of diversion (POD) for the Glenn-Gibson watershed. Within the urban growth boundary, approximately a half-dozen PODs for irrigation and two for recreation are located on Glenn Creek. Diversion rates range from 0.0030 to 137.00 cfs. Reservoirs are prevalent outside the UGB and are used for livestock, irrigation, fish, recreation and miscellaneous purposes. Inside the UGB, a few reservoirs along Gibson Creek are used for irrigation. Reservoirs used for miscellaneous purposes exist either on or near Glenn Creek. Reservoir storage ranges from 0.10–137.00 acre-feet in the Glenn-Gibson watershed.

Claggett Creek

Map 5-18 shows the types of water uses and points of diversion (POD) for the Claggett Creek watershed. Within the UGB, water is diverted for several uses including irrigation, municipal, and industrial uses as well as some recreation, agriculture and power. Diversion rates are low in the watershed and range from 0.0080-5.00 cfs. The OWRD database indicates that there is one reservoir in the Claggett Creek watershed with maximum storage of 1.2 acre-feet. The reservoir in question may actually be located just outside the watershed boundary on a slough of the Willamette River.

Mill Creek

Map 5-19 shows the types of water uses and points of diversion (POD) for the Mill Creek watershed. Outside the UGB, most water diversions are used for irrigation, municipal, domestic and livestock. A few points of diversion for power and miscellaneous are also depicted on the map. **Map 5-20** shows water use within the UGB. Irrigation, industrial and miscellaneous water uses predominate within the UGB.

Diversion rates vary for the Mill Creek watershed and range from 0.0020-230.00 cfs while reservoir storage ranges from 0.100-60.00 acre feet.

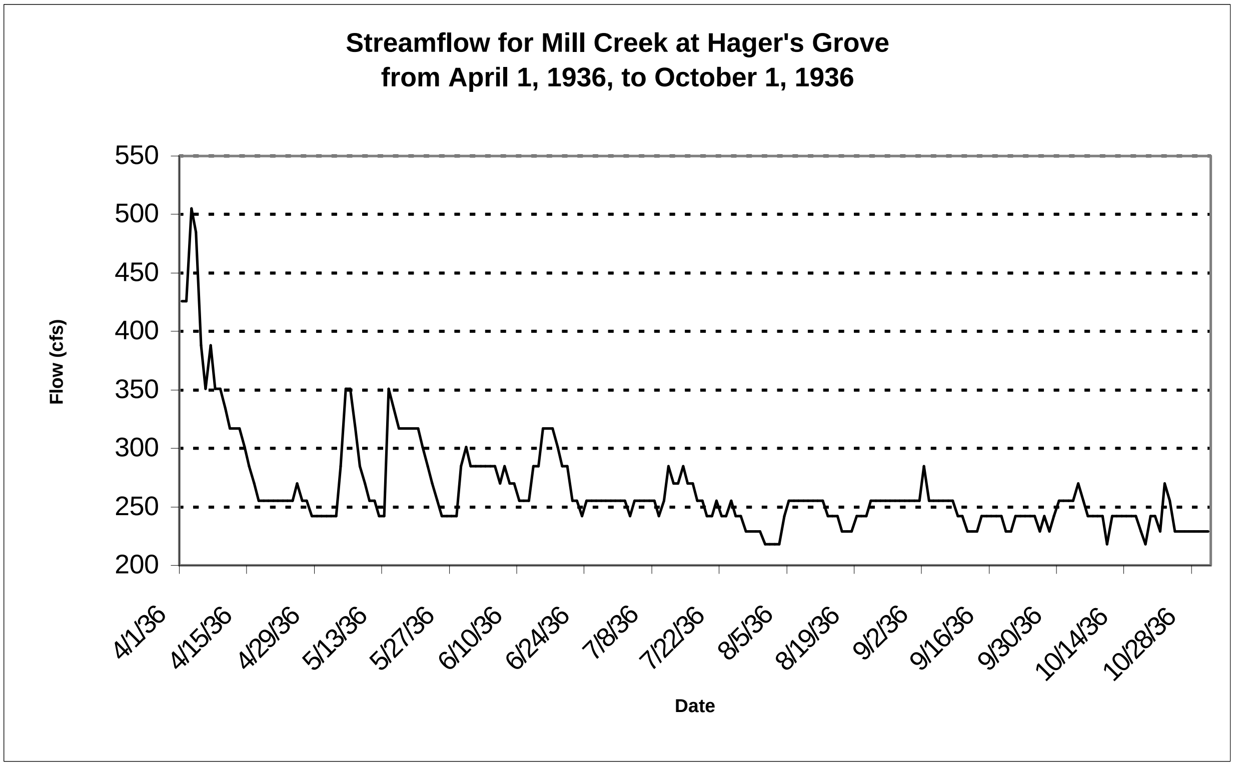
For more detailed information pertaining to discharge rates or reservoir storage within all four watersheds, please refer to the WRIS section of the OWRD website (OWRD 1997).

Streamflow and Water Diversions--Special Concerns

While the Oregon Department of Fish and Wildlife has not quantified any site-specific concerns such as lack of water in spawning reaches, inadequate adult fish passage, or insufficient flows for juvenile migration in Mill Creek (Galovich pers. comm.), watershed residents remain concerned about adequate streamflow and safe passage for fish in Mill Creek. The following section discusses these topics in relation to fish.

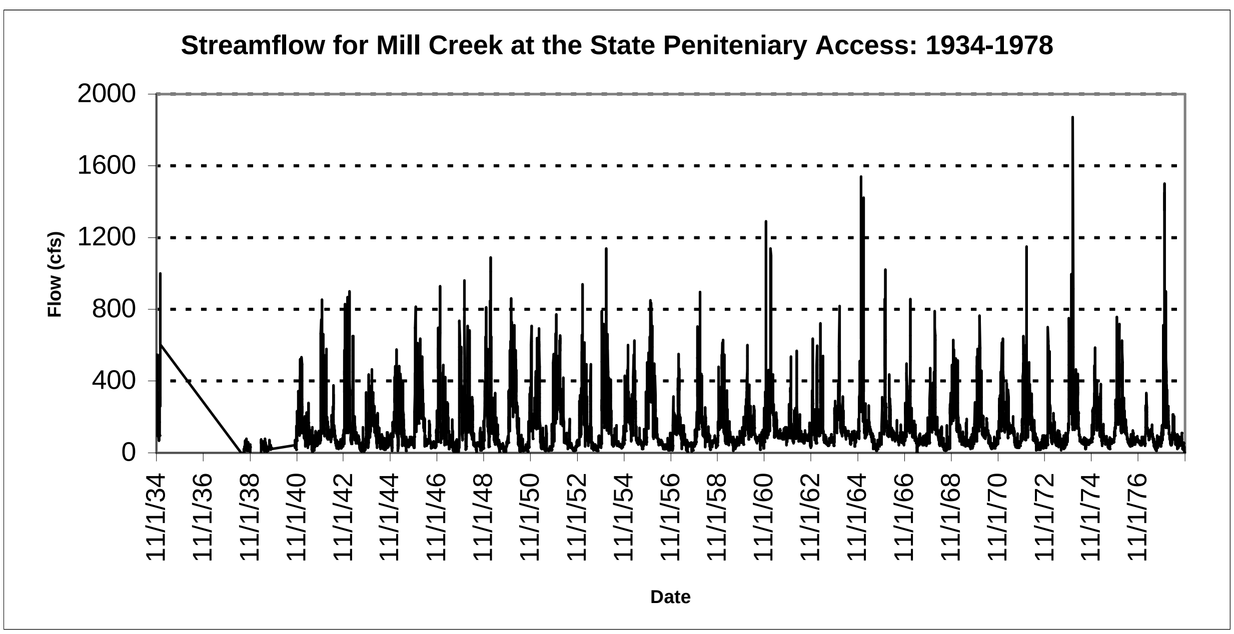
The presence of USGS and OWRD gauging stations within the Mill Creek watershed has allowed us to examine streamflow in Mill Creek. Streamflow records at Hager's Grove, the State Penitentiary and Shelton Ditch were used to examine flow patterns over time in Mill Creek. The flat line sections depicted on the graphs are the result of stage recorder malfunction (Ferber pers. comm.). **Figure 5-7** depicts streamflow at Hager's Grove from April to October in 1936. Streamflow decreases as dry weather begins to dominate in June. **Figure 5-8** illustrates the combined effect of both human and natural influences on Mill Creek flow patterns through a period of forty years. The tallest peaks are indicative of urban runoff, followed by medium peaks that depict upstream influences, and then smaller peaks that represent typical rain events (Ferber pers. comm.). Flow patterns for the Shelton Ditch from 1938 to 1950 fluctuate with high winter flows followed by low summer flows (**Figure 5-9**).

Figure 5-7.



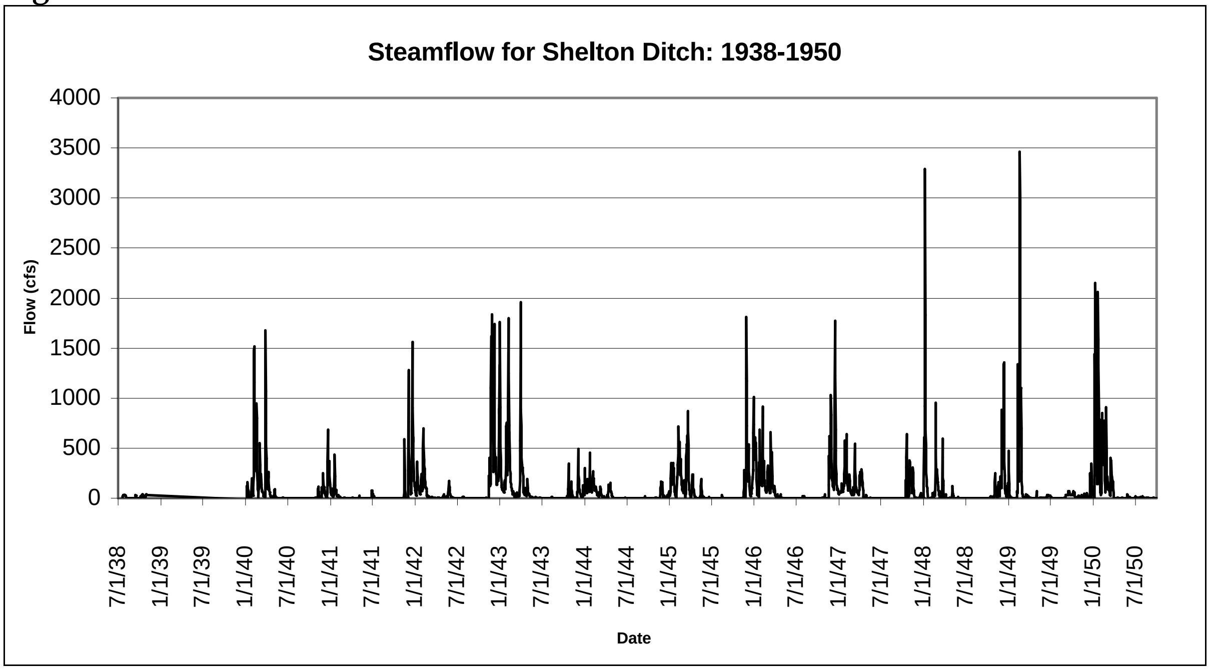
Source: ODWR (2001)

Figure 5-8



Source: ODWR (2001)

Figure 5-9.



Source: ODWR (2001)

Water diversions remove water from streams and lakes for drinking water, growing food, producing power, and many other purposes. Unprotected diversions also move fish, along with the water, out of streams and lakes. Fish that end up in unprotected diversions, such as pump irrigation systems and power turbines, frequently die (OWRD 1997).

The following areas outside of Salem's UGB are "points of interest" for safe fish passage and adequate streamflow for fish in the Mill Creek Watershed (Trosi pers. comm.; Hunt pers. comm.). These "points of interest" may require further discussion among stakeholders in the watershed (**Map 5-21**):

Points of Interest:

1. The Salem Ditch located west of Stayton
2. Irrigation dams at Kuebler Road
3. The many irrigation ditches located throughout the area approximately south of Turner and west of Stayton
4. The Power Canal and associated turbines in Stayton

The flow and channel characteristics of Mill Creek have been substantially modified by efforts to drain farmland, distribute water for agricultural and industrial uses, reduce flood damages, and provide for stormwater drainage. The long-standing diversion of water from the North Santiam River into Mill Creek has significantly changed the natural hydrology of the creek (MWVCOG 2000). Without this diversion there would be much lower summer flows in Mill Creek, making the flow more typical of similar watersheds not sustained by snow melt. Water diverted from the North Santiam River is distributed throughout the Mill Creek watershed using a combination of canals and ditches, including the Salem Ditch in Stayton and the Perrin Lateral Canal in Turner. It enters Mill Creek at Golf Club Road via the Salem Ditch. This diversion provides for the City of Salem's water rights, a portion of which dates back as far as 1856 (Trosi pers. comm.).

The diversion provides a total water right of 102 cfs to the City of Salem during summer months and is used to run Mission Mills' historict water-driven power turbine, as well as for recreation and aesthetic purposes such as the Civic Center Mirror Pond (Schweickert pers. comm.). A gauge station and meter located at the Salem Ditch allows the SWCD to regularly monitor streamflow and ensure that water levels are maintained (Trosi pers. comm.). If water cannot be released into the Salem Ditch due to low flows or high usage during the year, then the SWCD supplements water to Mill Creek at two other locations, Porter Creek and McKinney Creek. The main criterion used in deciding how much water is available to flow into the Mill Creek system is based on water rights.

An irrigation dam is located on Mill Creek at Kuebler Road. The SWCD operates the dam during the growing season. The boards used to impound the water are removed for the remainder of the year (Mauldin pers. comm.). More specifically, the SWCD places the boards at the dam during April or May and subsequently removes the boards either at the end of September or early October (Trosi pers. comm.).

The many irrigation ditches located throughout the western portion of the Mill Creek watershed have altered the way water historically flowed through the basin. The area south of Turner is a combination of natural and man-made ditches which may divert adult fish traveling upstream throughout the Mill Creek watershed (Hunt pers. comm.). Because this area serves both water users and migrating fish, further discussion is needed among stakeholders in the watershed to fully assess the impact of water diversions on migrating fish and how to provide alternatives to conflict between irrigation and fish use.

Another water diversion, which may impact fish passage, is the Power Canal. It diverts water from the North Santiam River for irrigation purposes. The canal extends from Stayton into the western portion of the Mill Creek watershed. Luckily, most pump sites located within the Power Canal system do have fish screens (Trosi pers. comm.). The Santiam Water Control District, along with two private entities, also operates four turbines in the Power Canal. The three turbines currently operating contain fish screens. The district plans to screen the entire Power Canal before the fourth turbine is placed into operation. While ODFW does not feel that the existing district screens meet current standards, it will not press to have the screens updated unless the plan to screen the entire canal doesn't work out (Hunt pers. comm.).

The Mill Race is another water diversion that may hinder the safe passage of fish. Located in the City of Salem, it diverts water from Mill Creek to feed the powergenerating turbine at Mission Mill. The City of Salem plans to screen the Mill Race by 2003 (Downs pers. comm.).

In summary, adequate streamflows and well-placed fish screens could make the Mill Creek Watershed more fish-friendly. Steps to improve passage and streamflows will require a combined effort from state and local agencies and the watershed's many water users.

Stormwater Management in an Urban Environment

U.S. urban areas were originally designed to maximize land use and density. The task of city planners in the past was to plan, design and implement an infrastructure system to service the urban area. Many roads, highways, sewer lines and stormwater systems were designed to a minimum standard for the urban area. Little attention was given to upland watershed areas or the surrounding suburban and rural areas. Basically no consideration was given to future stormwater flows (Seyfert 1978).

In the 1950s and 1960s, rapid population growth spurred development in suburban areas; however, infrastructure was still designed according to older standards. Planning and zoning objectives lagged behind the times, only concerned with the placement of subdivisions, shopping malls, and commercial and industrial centers. Little thought was given to the impact of development on natural systems (Seyfert 1978).

Until recently, the goal of stormwater management in many municipalities was to get water off a site and into a receiving stream or water body as fast and efficiently as possible. This philosophy of stormwater management expedited water removal, but also increased stormwater quantities and velocities.

.Stormwater quantity and quality may be the most important factors affecting fish habitat in urban areas. The change of water flow dynamics in many urban streams has led to accelerated rates of bank erosion and channel scouring, and extreme low flows during summer months. High flow events scour the channel and flush out spawning gravels and redds. Low flows during the summer may force salmonids into isolated pools, stranding them from the rest of the creek (Portland Multnomah Progress Board 2000).

Salem's Stormwater Infrastructure

Most cities are drained by an elaborate network of storm drains and open channels that carry urban runoff from streets, parking lots, and roofs to the nearest stream or water body. Salem provides stormwater drainage service to approximately 137,000 people within the city limits. The city's overall service area encompasses 150,000 to 160,000 people within the greater Salem Metropolitan area, as represented by the City of Salem's UGB (City of Salem Public Works Department 2000). Salem's stormwater collection system consists of the following structures. Information in **bold** is current as of July 26, 2001, and is estimated for structures/stream miles within Salem's UGB (Downs pers. comm.; Pennington pers. comm.):

561 miles of storm drains ("closed system" or piped system)
12,842 catch basins
95 miles of drainage and roadside ditches ("open system")
66 miles of stream ("open system")
50 bridges longer than 20 feet (inside city limits only)
128 stream crossings (inside city limits only)
2,100 grates/trash racks (inside city limits only)

Information regarding the conveyance system by watershed is shown in **Table 5-8**. The Mill Creek watershed, including Battle Creek, has the most open miles of stream within Salem's UGB. Including ditches as part of the open system gives the Pringle Creek watershed the most extensive open system, totaling almost 50 miles of creeks and ditches. The Pringle Creek watershed also has the most extensive closed system (i.e., storm drains and culverts) compared to the other three watersheds.

Table 5-8. Stormwater collection system within the Salem-Keizer urban growth boundary for four watersheds.

	OPEN SYSTEM	--------------- CLOSED SYSTEM ------- --------------------			
Watershed	Stream Length (miles)	Open Ditches (miles)	Storm Drains (miles)	No. of Culverts	Total Length of Culverts (miles)
Pringle	18.77	31.19	164.16	1007	6.38
Glenn-Gibson	6.52	2.21	40.42	399	2.24
West Bank[1]	0.76	3.39	34.38	133	0.87
Claggett[2]	3.34	10.95	76.37	492	3.33
Mill	19.48	24.28	141.72	714	5.11

[1] West Bank is located in West Salem and drains to the Willamette River via a piped system. The Glenn-Gibson Watershed Council may include and represent residents of the West Bank as part of their council.
[2] Only includes that part of the storm drain system that is in the upper portion of the watershed, south of the Salem Parkway. No information is available for the lower portion of the watershed, including the City of Keizer.
Source: City of Salem Public Works Department (2000)

If you divide the miles of storm drains and culverts by the total number of miles in the stormwater collection system for each watershed, you get an idea of how much the natural drainage of the watershed has been modified. Approximately 85% of the drainage in the upper Claggett Creek watershed is piped. Glenn-Gibson watershed follows closely behind with 84% in a closed system. Mill and Pringle are 77% and 78%, respectively. Of course, the piping does not include channel modifications made to the actual creeks themselves, such as channelization, riprap along stream banks, diking, or the construction of levees. Modifications to the open system are discussed in the Channel Modification Chapter.

City of Salem's Stormwater Master Plan

With increasing concerns about water quality and urban stream health, communities are now demanding multi-use solutions to stormwater management. The City of Salem and its 15 member Stormwater Advisory Committee worked together to develop a stormwater master plan that could effectively balance reductions in flood damages with improvements in stream water quality.

Published in February of 2000, the City of Salem's Stormwater Master Plan addresses issues of stormwater quantity (i.e., conveyance and flood damage reduction) and stormwater quality as it relates to Salem's National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit. During the study, spring Chinook and winter steelhead were listed as threatened species under the Endangered Species Act. The listing has implications on how Salem manages its stormwater, though there had been no federal-rule making as of the date the Master Plan was published. Therefore, the Stormwater Master Plan only initiates the process for examining stream enhancement and fish restoration, with the expectation that amendments will follow as the ESA rules are implemented. The plan was adopted by City Council in September 2000.

The two goals of the Stormwater Master Plan are to develop a Stormwater Management Program Plan (SMPP) and a Drainage System Improvement Plan (DSIP). The SMPP deals with the institutional aspect (policies, standards, and procedures) of a stormwater management program. Aspects of the SMPP include, among many others:

- Developing an erosion control ordinance and technical guide.
- Developing stream buffer ordinances.
- Identification of "significant" wetlands that need protection.
- Expansion of a public involvement and education program on flood management.

Many of these items have been completed or are in the process of completion.

The DSIP, the second goal of the Stormwater Master Plan, includes a comprehensive list of recommended drainage system improvements It is a product of the policies developed in the SMPP, the results of hydrologic-hydraulic modeling, City staff experience and records of past flood events. The DSIP includes a list of improvements for the storm drains, culverts, open channels, streams, detention storage, and conjunctive use water quality facilities. Project prioritization and design will be influenced by Salem's Best Management Practices to meet Clean Water Act requirements, the Endangered Species Act listings and the water quality status (i.e., 303(d) streams) of several of Salem's streams.

The types of drainage system improvement projects in the DSIP range from replacing undersized pipes to making stream habitat improvements. **Table 5-9** lists project types and the number of proposed projects per watershed. There is no analysis of the effects of the proposed stormwater improvements on the local hydrology or stream channel conditions.

Table 5-9. Drainage System Improvements by Watershed[1]

	Pringle	Glenn-Gibson	Upper Claggett[2]	Battle	Mill[3]
Add or Improve Bridges	17	5	3	6	0
Replace Undersized Pipes	12	5	37	0	27
Replace/Remove Undersized Culverts	18	8	18	10	13
Channelization/Bioengineering/Special Stream Habitat Improvements	21	2	10	13	4
Add Regional Detention Facilities	3	6	1	2	0

Source: adapted from City of Salem Public Works Department (2000)
[1] Proposed drainage system improvements are only for the portion of Claggett Creek watershed within Salem-Keizer UGB south of the Salem Parkway.
[2] The study focused on the portion of Mill Creek watershed within the urban growth boundary.

The category entitled "Channelization/Bioengineering/Special Habitat Improvements" is of special interest to watershed councils because stream enhancement is a project priority for watershed councils. The purpose of stream enhancement is to improve water quality and aquatic habitat conditions for salmonids and other species adapted to cold, clean water. Where the priorities of the watershed councils and the DSIP overlap, project coordination between the councils and the City of Salem will help advance the implementation of the project.

The different components are defined in the Stormwater Master Plan as presented below:

"Channelization" refers to capacity-increasing and erosion-preventing types of projects in waterways and ditches. It generally involves widening of channels by gently sloping the (usually) incised banks back away from the waterway to create a more stable, less steep slope; and removing obstructions such as accumulations of trash and debris, non-native brush, diseased or unstable trees, old concrete walls or riprap which impede the free flow of water. Channelization will result in improved "capacity" but can have adverse ecological effects. While channelization is generally done in combination with bioengineering or stream habitat work, it can also be done as a stand-alone project.

"Bioengineering/Habitat" refers to restoration efforts primarily aimed at stabilizing waterway banks through the use of mostly living materials as ground cover, such as closely planted/densely rooted trees or low-growing hardy native species; placing tree trunks, larger rocks or small constructed flow-diverting structures at critical erosion-prone locations and creating velocity dissipaters or meanders in the waterway bed. Temporary stabilizing materials to help prevent erosion or slumping are used until the plants can take hold and include burlap or coconut fiber blankets.

"Special Stream Habitat" refers to more extensive waterway restoration efforts to restore or enhance both the stream channel and the riparian zones. It includes both in-stream restoration of waterway channels (spawning gravels, riffles, backwaters, and woody debris cover areas), and attention to stream shading through selected native tree planting, brush cover and habitat areas.

Stormwater detention facilities are another capital improvement of interest to watershed councils. Stormwater detention facilities can be either ponds, underground tank vaults or oversized pipes specifically designed to capture, store and then slowly release stormwater runoff downstream. In addition to helping prevent flooding and erosion, detention facilities help protect water quality by incorporating features that filter or remove sediments, excess nutrients and toxic chemicals. In some cases ponds (and other open air structures for improving water quality) provide feeding, nesting and hiding places for many species of fish, birds and reptiles (King County Department of Natural Resources 1999).

Drainage System Improvements by Watershed

The locations of potential DSIP projects involving channelization, stream enhancement, bioengineering, and detention facilities are summarized below. The main goal of DSIP projects is to improve drainage. Projects were **not** specifically chosen because of their potential for stream enhancement. Where feasible, stream enhancement is included as a secondary goal of DSIP projects. The project numbers on the following maps refer to specific projects identified in the DSIP. For more detailed information on specific projects, please refer to the Stormwater Master Plan.

Pringle Creek Watershed

Many of the proposed stream enhancement projects are located on the East Fork of Pringle Creek along the railroad right-of-way (**Map 5-22**). More work remains to be completed throughout Fairview Industrial Park on the Middle Fork. Other protections should be undertaken for portions of the West Fork and for the entire West Middle Fork, especially in light of the planned development of the Fairview property.

Other potential projects include several reaches of the West Fork of Pringle Creek as it stretches on the west side of Commercial from the Pringle Creek Nature Preserve to Woodmansee Park and the Carson Natural Area, and then upstream through residential backyards to the creek's headwaters above Cannery Park. East of Commercial, opportunities exist to evaluate the series of dams and weirs in residential subdivisions where some neighbors have already enhanced back gardens along the creek, but others can use help. The reach at Leslie Middle School offers potential for enhancement in conjunction with a potential detention basin. Challenges include poor ballfield drainage, parking lot drainage treatment and previous mitigation projects at the school.

Several reaches of Clark Creek, such as that from Ewald SE to Halifax Square, would benefit from enhancements. Dams and weirs south of Madrona and west of Hillview could be removed. East of Commercial, areas benefiting from projects include reaches from Willow Court through Clark Creek Park, between Winter and Summer Streets, and around Gilmore Field and along the east side ballfields at South Salem High School.

Clark Creek has two existing stormwater detention facilities: Gilmore Field and Clark Creek Park. Potential locations of two additional detention facilities in the Pringle Creek watershed are Leslie Middle School on the West Fork and Webb Lake on the East Fork. Several detention facilities in Salem are proposed in current public parks/school grounds or in locations of future parks. Past practice has been less than successful because the ballfields and playfields have been too wet to use for their primary intended purpose: play. In addition, Clark Creek Park provides park amenities in an already well-developed area where no additional park facilities are possible because no land is available. This is a public policy issue that will be revisited many times and the solution will have to balance multiple uses in limited space.

Glenn-Gibson Watershed

According to the DSIP, the proposed drainage system improvement projects in the Glenn-Gibson watershed provide little opportunity for stream enhancement. Only two projects involving stream conveyance are proposed for the watershed. Both proposed projects lie along Glenn Creek Road just west of the creek's intersection with Orchard Heights Road (**Map 5-23**).

Six regional detention facilities, two along Glenn Creek, and four in the Gibson Creek basin, are proposed in the DSIP. The two on Glenn Creek would be located at Orchard Heights Park and just upstream from Glen Eden Court. Two detention facilities on Gibson Creek would be near Grice Hill Road; the third one would be at Gladow Pond just upstream of Orchard Heights Road, and the fourth at the Holiday Tree Farm. Which ones will be constructed has not yet been decided.

Upper Claggett Creek Watershed

Most of Upper Claggett Creek has been piped, so many of the proposed projects involving streams are in the lower portion of this sub-basin (**Map 5-24**). Ten stream conveyance projects are proposed in the DSIP for the Upper Claggett Creek Basin. The projects are located in four main areas: Claggett Gravel Pits (near Portland Road), Lancaster Drive, Hawthorne Avenue, and along Ibex Street and Ward Drive.

Upper Claggett Creek contains two City-owned regional stormwater detention facilities: Eastgate Basin Park and an area near the intersection of 37^{th} Place and D Street. Oregon Department of Transportation (ODOT) has an additional detention facility in area between NE Fisher and I-5, just south of the Highway 99 interchange. ODOT's detention facility serves the I-5 drainage. An additional regional detention facility is proposed at the proposed Northgate Park site.

Mill Creek Watershed (Including Battle Creek)

The DSIP has identified four potential stream capacity projects in the Mill Creek watershed within Salem's urban growth boundary. Three of the four proposed projects are located between the Salem Airport and the I-5/Highway 22 exit. All four projects involve channelization of roadside ditches in order to increase their capacity for stormwater. None of the projects involve alterations to Mill Creek itself (**Map 5-25**).

Because much of the Mill Creek watershed lies outside of Salem's urban growth boundary, the DSIP did not evaluate Mill Creek using a hydrological model upstream from the UGB. Previous studies have shown that flood damage reduction in the Mill Creek system can't be achieved through conveyance improvements within the city of Salem. The U. S. Army Corps of Engineers (COE) has been studying potential regional solutions for flood reduction in Mill Creek, in order to identify major flood mitigation projects, some of which may be located in the upper reaches of the Mill Creek watershed. While potential regional detention opportunities exist upstream from Turner, the COE's final report concluded that none met their regional minimum cost-benefit ratio.

Battle Creek, a tributary to Mill Creek, has 13 proposed stream conveyance projects, according to the DSIP. Almost all the projects lie along Battle Creek and its tributaries (Waln Creek, Jory Creek, and Powell Creek) between I-5 and Sunnyside Road, including reaches of Battle Creek and Waln Creek that flow through Battle Creek Golf Course (**Map 5-26**).

Two proposed regional detention facilities are located in the Battle Creek basin. Both would be located along Liberty Road, outside of the Urban Growth Boundary (UGB), one facility in the upper reaches of Jory Creek, the other in Battle Creek.

Future Model Enhancement

The hydraulic model used to determine the types and locations of drainage system improvements needed to alleviate flooding in each watershed was adequate for master plan development. However, verification and design of the individual improvement projects will require a more detailed model. A refinement of the hydraulic model is considered an "Early Action Item" in the Stormwater Master Plan. Field data will need to be collected on a variety of factors, including rainfall and runoff amounts and culvert and channel dimensions. Once the data has been collected and incorporated, the model can be used to refine the operation of hydraulic structures, define surcharge levels for culverts and manholes, and perform a more detailed analysis.

Implementation of DSIP

The DSIP outlines specific flood improvement projects. Approximately $203.5 million will be needed for flood improvement projects within Salem's UGB (not including Keizer). Funding for DSIP projects will mainly come from utility ratepayers. The projects will be implemented over time to avoid abrupt rate increases. Some "Early Action Items" (see Stormwater Master Plan) are already in progress. Remaining DSIP projects will be prioritized once funding for stormwater management projects and associated regulatory program requirements (i.e., TMDLs and Endangered Species Act) become clearer.

Another $3 million has been allocated for a system inventory, monitoring program and hydraulic model enhancement. The system inventory and monitoring program are necessary in order to develop more detailed hydraulic models that can be used to design individual flood improvement projects.

The DSIP also has two proposals for Water Quality Facilities (i.e., projects that improve water quality) and Stream Restoration/Habitat Improvement. Projects in these two categories will be prioritized as part of the City of Salem's annual rate funded "Pay As You Go" funding program. Four million dollars has been allocated for implementation of regional water quality facilities. Another $6.1 million has been allocated for stream/habitat improvement projects. No specific projects have been identified for either of these two categories. Requirements of the Stormwater National Pollutant Discharge Elimination System program, Endangered Species Act, and the Total Maximum Daily Load (TMDL) program are still unclear, and will not be fully known until the Willamette River TMDL is established in 2003. Project prioritization will occur once stormwater management funding and regulatory requirements are clarified.

Summary

The data and information in this chapter reveal some of the many effects of land and water use on watershed hydrology in urban and rural conditions. Pringle, Glenn-Gibson, Claggett and Mill Creek are low elevation watersheds that are highly urbanized. The headwaters of Mill Creek differ from the other watersheds by being located in the foothills of the Cascades. All four basins have distinct topographic and hydrologic features that affect historic and existing drainage patterns. The construction of the Mill Race, Shelton Ditch and Salem Ditch show how humans have modified the natural movement of water in both the Pringle and Mill Creek systems.

The Salem area's previous floods and local weather patterns guarantee occurrence of future floods. The construction of dams on the Willamette River has reduced the frequency of flooding and flood levels on the main stem of the river. Many of the Willamette's smaller tributaries are also managed. Stream channelization in the

Salem area allows large volumes of water to move quickly throughout the urban landscape. As a result, urbanization causes downstream hydrographs to demonstrate higher-than-natural flood peaks.

The information in this chapter also illustrates how native fish species are impacted by both peak and low streamflows. Peak winter flows, exacerbated by urbanization, can negatively impact adult spawning activities by washing out gravels and redds. Low summer flows can negatively affect juvenile rearing habitats by isolating fish in small pools and increasing water temperatures. Most water rights in the four watersheds have probably been allocated for irrigation use. But water rights and water use in the OWRD database have not been updated to reflect current conditions. Nor have historical water rights no longer in use been purged from the database. The handful of industrial and municipal users in the four watersheds have been allocated large water rights and are probably using a significant amount of ground and/or surface water in the watersheds. A comparison between allocation and use is needed to determine if water rights are over-allocated in any of the four basins.

The chapter also identifies the variety of land and water uses in the watersheds. The amount of impervious cover in each watershed indicates the extent of urbanization. Previous studies show how stream degradation occurs with as little as 10% imperviousness and may influence peak flows, urban pollutant loads, increased stream temperatures, and the overall health of local aquatic systems. Both Pringle and Claggett Creeks are currently considered “impacted” streams. Fifty-five percent of the developed acres in Salem are impervious surface, and 42% of the land inside the UGB is covered by impervious surface as of 2000. Most of the waterways associated with Pringle, Glenn-Gibson, Claggett and Mill Creeks are affected. Estimates of the amounts of impervious surface in the Glenn-Gibson and Mill Creek basins are currently below 10%, thus ranking the creeks as “sensitive”. With continued development in the watersheds, all creeks have the potential of becoming “non-supporting” streams. Non-supporting streams have limited aquatic diversity. The life in these streams is mainly composed of pollution-tolerant insects and fish.

Water diversions, and other structures, may impose a threat to safe fish passage. Important areas in the Mill Creek watershed have been identified and warrant future discussion as to water diversion and fish passage. The City of Salem has completed an inventory of fish passage barriers; see 9-23 through 9-28.

To counteract increased peak flows and decreased summer flows, the City of Salem has incorporated wetland restoration and enhancement of both stream channels and riparian zones into their Stormwater Master Plan (City of Salem Public Works Department 2000). The City of Salem has identified wetlands that provide “significant” functions, such as flood retention, and is establishing additional protection by local ordinances. An erosion control ordinance approved by the Salem City became effective as of September 1, 2001. An ordinance protecting trees within a 50-foot buffer along perennial streams, and protecting trees and native vegetation within 50 feet of fish-bearing streams took effect in June 2000.

Recommendations

All Basins

1. Work with the Oregon Water Resources Department (OWRD) to determine the consumption by basin and learn if water rights are over-allocated based on streamflow. Modeling to estimate this data will require substantial funding.

2. Encourage OWRD to update its database on water rights and water users to reflect current conditions. This will help to determine if water is being over-allocated.

3. A water right must be used at least once every five years; otherwise the right is subject to cancellation. There is no system in place to monitor or regulate the amount of water withdrawn. Work with the OWRD to identify unused water rights and implement administrative proceedings to determine the validity of the water rights and alternative distribution options.

4. In partnership with Oregon Water Trust **(http://www.owt.org/),** OWRD encourages all water right holders to donate, lease or sell all or part of an unused water right back to the stream so that the water can be used for aquatic life and fisheries. The watershed councils should collaborate with these entities to identify potential "water donors."

5. Work with OWRD to determine ownership of weirs, dams or other obstructions within stream channels that may no longer be in use for water allocation purposes. Take action to eliminate these unnecessary obstructions to fish passage.

6. Establish long-term wetland protection, enhancement and mitigation strategies on a regional watershed basis. For example, as much as 1,500 acres at Lake Labish should be considered for multi-use wetland mitigation, floodwater storage, water quality treatment, recreational opportunities and wildlife habitat/refuge.

7. Focus on how to protect the sensitive areas at the edge of the UGB, with the long-term goal of creating an "emerald necklace" around Salem's UGB which connects to sensitive areas and refuges and protects prime farm and forest lands outside the UGB.

8. Reduce, prevent, or mitigate the creation of more impervious surfaces. Future land use efforts should be broadened to include alternative planning strategies

when designing streets and parking lots. To reduce the impact of increased impervious surfaces, parking lot bio-swales or "wet ponds," vegetated buffers and regional stormwater detention basins should be incorporated into development plans. Work with local governments to establish standards aimed at better integration of transportation and drainage systems, as proposed by the Pringle Creek Watershed Council to Salem's Transportation Planning Manager on the City's proposed Sidewalk Construction and Maintenance Plan (SCAMP). Additional efforts may include identifying areas that could be converted into multipurpose (bicycle, pedestrian, wildlife, natural drainage) "greenway" corridors and refuges. Possible future collaboration may include the City of Salem, local municipalities, Oregon Department of Transportation (ODOT), and other state agencies.

9. Work to create conservation easements and other legal methods to protect both private and public sensitive natural areas along all Salem's streams.

10. Build and expand community-wide education programs to enlist broad-based and long-term support for watershed protection, enhancement and restoration.

11. Partner with the City of Salem on Drainage System Improvement Projects (DSIPs) that incorporate wetland restoration and stream enhancement (i.e., reconnecting creeks to their historic floodplains) for use as flood abatement.

12. Partner with the City of Salem on determining the location and design of regional stormwater detention basins. The process should take into account the primary purpose of land and should not negatively impact it. For example, if parkland or school ball fields are used for detention, their recreational purposes should not be degraded.

13. Identify additional project sites beyond those listed in the DSIP for stream enhancement and wetland restoration opportunities.

14. Build and expand community-wide education programs to enlist broad-based and long-term support for watershed protection, enhancement and restoration.

15. Determine and map the locations of springs and seeps in the each of the four watersheds.

16. Identify all diversions that require fish screens.

17. Locate, map and determine the status of water rights and groundwater wells on both public and private property.

18. Determine ownership and responsibility for operation, maintenance and retrofit for culverts identified as undersized or inadequate.

19. Determine the impact of Salem's water/sewer/stormwater projects on Salem's streams.

20. Document time required for major public works projects and large scale private developments to recover from disturbances, and the related impacts on native and invasive species.

21. Serve as a clearinghouse/library to facilitate project implementation, watershed outreach, and policy development by local stakeholders.

22. Produce baseline ecological descriptions of the ecosystems and stream reaches needing protection, enhancement or restoration.

23. Conduct and inventory of exotic plant and animal species currently present in Salem's watersheds.

Pringle, Claggett, and Glenn and Gibson Creeks

1. Continuous monitoring will assist watershed councils, local government agencies, and OWRD in better understanding seasonal low flow problems and the stage/discharge relationship of these creeks. Currently Mill Creek is the only stream in the four watersheds that has a continuous monitoring station to check flow, water depth, and temperature. Continuous monitoring stations need to be installed at key locations in the other three watersheds.

Pringle Creek

1. Incorporate Aquifer Storage and Retrieval testing protocols and stream bank protections at Woodmansee Park.

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