CHAPTER EIGHT
Carbon River & Upper Puyallup River Basin

8.1 BASIN CHARACTERISTICS

The Carbon River and Upper Puyallup River Basin extends across northeastern Pierce County and incorporates all areas draining to the Carbon River and to the Upper Puyallup River in unincorporated Pierce County. For the purpose of Basin planning, parts of the Basin in cities and towns are considered insofar as they experience problems due to drainage conditions in Pierce County or they contribute to conditions in unincorporated areas. The Basin lies within Washington state's designated "Water Resource Inventory Area"(WRIA) 10, Puyallup-White.

The Upper Puyallup River begins at river mile (RM) 25.3 of the Puyallup River at the Orting High Bridge, where Oroville Road crosses the Puyallup River. It extends to the headwaters on Mount Rainier. Most of the Upper Puyallup River flows through national forest and privately-owned lands designated for long-term commercial forestry (forest land).

The Carbon River flows into the Puyallup River at the north end of the city of Orting. Basin plans and the Pierce County Water Programs "Capital Improvement Program" refer to this section of the Puyallup River the "Mid-Puyallup." The Carbon River and the Upper Puyallup River Basin are considered a single Basin for the purpose of Basin planning because they have similar geographic and land use characteristics lie adjacent to each other.

Table 8-1 summarizes the primary drainages (natural or artificial channels that transport surface water) in the Basin. In general, most of the drainages in the Basin cut through steep terrain. Drainages become less steep near the western end of the Basin. A few courses flow through the broad floodplain terraces of the Carbon or Puyallup Rivers. These include Kapowsin Creek and the unnamed Carbon tributaries #1 and #2. Subbasins such as Coplar Creek, Fiske Creek, Fox Creek, Ohop Creek, South Prairie Creek, Unnamed Fiske Creek Tributary, Voight Creek, and Wilkeson Creek consist primarily of forest lands. Most of the subbasins are rural, with the South Prairie Creek subbasin having the most residential development.

Elevations in the entire Basin range from 200 feet above sea level to over 14,000 feet at the top of Mount Rainer, at the southeast corner of the Basin. In general, the elevation increases from west to east throughout the Basin. The varied topography that characterizes the Carbon River and Upper Puyallup River Basin is the product of volcanic activity, tectonic uplifting, glacial advances and retreats, and erosion by rivers and streams.

Meteorological variables such as snow pack, temperature, precipitation distribution, and the intensity and orientation of the jet stream affect storm drainage and flooding. The climate of the Carbon River and Upper Puyallup River Basin results from the Basin's location along the western slope of the Cascade Mountains and near the Pacific Ocean. Moist, ocean air cools as it rises to cross the mountains, causing rain to fall on the western slopes. The Cascade Mountains also block the movement of cold air into the region, moderating winter temperatures. On average, the Basin's lower elevations (200 to 2,000 feet) receive 41 to 65 inches of precipitation per year. Higher elevations (2,000 to 4,000 feet) receive 65 to 93 inches of precipitation annually. The wettest months within the Basin are November through January, while the driest months are June, July, and August.

TABLE 8-1
CARBON RIVER AND UPPER PUYALLUP RIVER BASIN TRIBUTARIES

River/Tributary	Joins to	At River Mile
Carbon River	**Puyallup River**	**17.4**
Unnamed Carbon River Tributary #1	Carbon River	3.9
Voight Creek	Carbon River	4.0
- Coplar Creek	Voight Creek	0.8
- Unnamed Voight Creek Tributary	Voight Creek	not determined
South Prairie Creek	Carbon River	5.8
- Wilkeson Creek	South Prairie Creek	6.7
- Spiketon Creek/Ditch	South Prairie Creek	7.1
Unnamed Carbon River Tributary #2	Carbon River	6.4
Upper Puyallup River	**Begins**	**25.3**
Fiske Creek	Upper Puyallup River	25.4
Kapowsin Creek	Upper Puyallup River	26.0
- Unnamed Kapowsin Tributary #1	Kapowsin Creek	not determined
- Unnamed Kapowsin Tributary #2	Kapowsin Creek	not determined
- Ohop Creek	Lake Kapowsin	NA
Fox Creek	Upper Puyallup River	28.0

Soil permeability influences how water moves through and within soil layers. Most soils in the upper elevations of the Basin are moderately permeable. Soils in the lower elevations range from highly permeable to relatively impermeable. Soils in the lower elevations of the Basin are generally more permeable than those in the southeastern portion of the Basin. The Natural Resources Conservation Service (NRCS) has classified soils into hydrologic soil groups to indicate the rates of infiltration and transmission (NRCS, 1986). In the higher elevation portion of the Basins, the soils are classified as primarily "Group B", which indicates moderately well-drained loam with an infiltration rate of 0.15 to 0.30 inches per hour. Soils in the Buckley plateau are generally "Group D", indicating a very slow infiltration rate of 0 to 0.05 inches per hour. The western portions of South Prairie Creek Basin and the Carbon River Basin have "Group A" soils with infiltration rates greater than 0.30 inches per hour and "Group C" soils with infiltration rates of 0.05 to 0.15 inches per hour.

According to the Pierce County "Geographical Information System" (GIS) data, the Basin contains almost 2,500 acres of wetlands, covering about 2% of the entire area. Most the wetlands are located in the western half of the Basin, where lakes exist. The Carbon River and Upper Puyallup River Basin contains 26 lakes ranging in size from over 500 acres to less than 0.5 acre.

The Carbon River and Upper Puyallup River Basin is underlain by aquifers consisting of unconsolidated glacial deposits. Water generally flows freely through these deposits. However, the presence of fine-grained sediment in these deposits can restrict the flow of water. The degree to which flow is restricted by these fine-grained sediments is currently unknown.

A study in WRIA 10 delineated a layer-cake of five coarse-grained aquifers alternating with five fine-grained semi-confining units and underlain by deep undifferentiated deposits (Jones et al., 1999). Glacial deposits of the Basin are likely to contain similar geohydrologic units. The locations of these units in the Basin can be inferred from well logs and other information, but their precise locations are not known.

Although some types of volcanic rock formed from ash are very porous, the upper parts of the Basin contain volcanic rocks of a type that do not form productive aquifers.

Many of the sediment layers and aquifers extend beneath portions of adjacent watersheds to the north and south. Some natural groundwater exchange probably occurs between the watersheds. The extent of the exchange of groundwater between the watersheds is currently unknown.

Recharge to the groundwater system in the planning area is primarily through the infiltration of precipitation, and secondarily through seepage from surface water (lakes, ponds, and streams) and from anthropogenic effects (septic systems, irrigation return flow, water reuse, etc.). Human-induced recharge also occurs in more densely populated areas of the Basin from on-site sewer systems, irrigation, leakage from water/sewer lines, and direct infiltration of surface water runoff (infiltration ponds, dry wells, etc.). The areas with the highest rates of recharge are located in the upper portion of the Basin, where rainfall is also higher. The rates of recharge are uncertain in most areas.

Regional information regarding groundwater flow direction and elevations is not available for much of the Basin. However, where data are available, the flow has been reported as generally flowing to the northwest (Jones et al, 1999).

8.1.1 Carbon River and Upper Puyallup River Basin Planning Area

The planning area consists of the service area of the Pierce County "Storm Drainage and Surface Water Management Utility" in the Carbon River Basin and the Upper Puyallup River Basin. The planning area does not include those parts of the Basin that lie within incorporated towns and cities, timber lands designated by Pierce County for long-term, commercial forestry, or lands within Mount Rainier National Park, except where activities in these areas contribute to surface water management problems in unincorporated Pierce County or vice versa.

The Basin Plan also does not cover the main stem Carbon River and Puyallup River. The main stem Carbon River and Puyallup River are addressed in the *Puyallup River Flood Control Management Plan, 1991*. The *Puyallup River Flood Control Management Plan* concentrates on the floodplains and floodways of the Puyallup River and major tributaries where contributory flows from many Basins affect flood conditions. The planning area lies within the lower part of the Carbon River and Upper Puyallup River Basin, at elevations ranging from 200 to 1,000 feet. *Table 8-2* shows the subbasins within the entire Basin and presents the subbasin area that is contained within the Planning Area.

The planning area contains only two lakes (Lake Kapowsin and Morgan Lake) and three reservoirs (Electron Reservoir, Kepka Lake, and Sunset Lake). Lake Kapowsin is within the Kapowsin Creek subbasin, and Morgan Lake is within the Unnamed Kapowsin Tributary #2 subbasin. Both Morgan and Kapowsin Lakes are regulated by the Pierce County Development Regulations *Shoreline Management Regulations* (PALS, 2002). Both Sunset Reservoir and Kepka Lake are located within the South Prairie Creek subbasin. The Electron Reservoir is located within the Upper Puyallup River subbasin.

Lake Kapowsin is the larger of the two lakes, with a surface area of about 511 acres. Although the lake reaches depths of about 58 feet, most of it is shallow. The lake is located at an elevation of 600 feet. Morgan Lake covers about 66 acres in surface area and eventually drains to Kapowsin Creek north of

Lake Kapowsin. The lake lies in a depression on a terrace west of the Puyallup River Valley. The lake is owned by a single property owner on land with a current use assessment for agriculture.

TABLE 8-2
SUBBASIN AREAS

Subbasin	Total Area in square miles	Planning Area in square miles	Percent of Basin
Unnamed Carbon River Tributary #1	2.2	1.9	4.8%
Voight Creek	30.1	2.4	6.1%
Coplar Creek	2.3	0.7	1.7%
Unnamed Voight Creek Tributary	2.2	1.7	4.3%
South Prairie Creek	58.0	15.6	39.1%
Wilkeson Creek	28.7	6.1	15.3%
Spiketon Ditch	3.3	1.9	4.7%
Unnamed Carbon River Tributary #2	0.7	0.7	1.7%
Fiske Creek	1.7	1.0	2.4%
Unnamed Fiske Creek Tributary	0.9	0.3	0.7%
Kapowsin Creek	10.6	5.3	13.2%
Ohop Creek	15.1	0.5	1.2%
Unnamed Kapowsin Tributary #1	0.3	0.3	0.8%
Unnamed Kapowsin Tributary #2	1.9	1.6	3.9%
Fox Creek	5.1	<0.1	<0.1%
Total	**163.2**	**39.9**	**100%**

8.2 LAND USE IN THE BASIN AND PLANNING AREA

The Carbon River and Upper Puyallup River Basin largely consists of national forest and privately-owned lands designated for long-term, commercial forestry (forest land). The area designated as the planning area consists primarily of rural residential land uses.

8.2.1 Existing Land Use in the Planning Area

The eastern portion of the Basin is comprised of open space and resource lands, with very little development. This includes National Park Service land (Mount Rainier National Park) and National Forest Land (Mount Baker-Snoqualmie National Forest). The western portion of the Basin, which incorporates the planning area, includes some residential areas between open space and resource lands. Northeast of Wilkeson, the Seventh Day Adventist Church has a large parcel of land that, according to GIS records, is a camp site. In the Upper Puyallup River Basin, there are some transportation/ communication/utilities parcels owned by Puget Sound Energy, including the Electron Hydroelectric Project. The approximate extent of land uses in the hydrologic Basin and planning area is listed in T*able 8-3.*

TABLE 8-3
EXISTING LAND USE IN THE BASIN AND PLANNING AREA

Land Use	Basin	Planning Area
Commercial/Industrial	<1%	<1%
Education	1%	<1%
Open Spaces/Resource Lands	46%	38%
Public Places/Religious Centers	1%	1%
Residential	24%	28%
Transportation/Communication	2%	2%
Vacant Land/Undefined	27%	31%
Total	**100%**	**100%**

8.2.2 Future Land Use

The *Pierce County Comprehensive Plan* was developed and adopted in 1994 in response to the requirements of the Washington State "Growth Management Act"(GMA). The Plan, codified as *Title 19A, Pierce County Code*, indicates a general intention to allow development to the Basin boundary with residential densities ranging from one unit per 10 acres to six units per acre. The Pierce County Zoning Ordinance is codified in *Title 18A, Pierce County Code*. In the future, urban uses will occupy 81& of the land surface.

The "Growth Management Act" provides goals and guidelines for development of growth management plans addressing urban growth. This Act mandates consistency between county comprehensive plans and plans of all municipalities in the county. The *Pierce County Comprehensive Plan* provides county-wide policies in cooperation with all cities and towns in the County. These 11 policies are: affordable housing; agricultural lands; economic development; education; historic, archaeological and cultural preservation; natural resources; open space and protection of environmentally sensitive lands; determining site locations for public capital facilities of a county-wide or state-wide nature; transportation facilities and strategies; urban growth areas; and amendments and transition.

The "Growth Management Act" includes the following goals for development:

- **Urban Growth**—Encourage development in urban areas where adequate public facilities and services exist or can be provided in an efficient manner.
- **Reduce Sprawl**—Reduce the inappropriate conversion of undeveloped land into sprawling, low-density development

Pierce County has an additional goal of containing urban sprawl by designating an urban/rural boundary, and focusing infrastructure development in proposed employment centers and near cities and towns where a full range of urban services is available.

The future land use designations that lie within the Carbon River and Upper Puyallup River Basin are listed below.

- Agricultural
- Designated forest land
- Employment-based planned community
- Moderate density single-family
- Mount Rainer National Park
- Rural five (density of 1 dwelling unit per 5 acres)
- Rural 10 (density of 1 dwelling unit per 10 acres)
- Rural 20 (density of 1 dwelling unit per 20 acres)
- Rural neighborhood center

Most of the Basin planning area is currently zoned Rural 10, while most of the remainder of the Basin is designated forest land. Based on the zoning, the planning area is likely to remain primarily rural residential as seen in *Table 8-4*.

TABLE 8-4
PERCENT OF URBAN GROWTH AREAS IN THE BASIN

Subbasin	City Urban Growth Area (%)	County Urban Growth Area (%)	Rural County (%)
Unnamed Carbon River Tributary #1	0	0	100
Voight Creek	0	0	100
Coplar Creek	0	0	100
Unnamed Voight Creek Tributary	0	0	100
South Prairie Creek	<1	26	73
Wilkeson Creek	0	0	100
Spiketon Ditch	0	0	100
Unnamed Carbon River Tributary #2	0	0	100
Fiske Creek	0	0	100
Unnamed Fiske Creek Tributary	0	0	100
Kapowsin Creek	0	0	100
Unnamed Kapowsin Tributary #1	0	0	100
Unnamed Kapowsin Tributary #2	0	0	100
Fox Creek	0	0	100
Ohop Creek	0	0	100

8.2.3 Planned Developments

Although the Basins are zoned to remain primarily rural residential, there are two known major developments planned and/or underway within the Basins-The Buttes and Cascadia.

The Buttes

Construction of "The Buttes" development is partially complete. The development is southeast of Orting, between Coplar Creek and the Puyallup River. The development sits high above the Orting Valley at an elevation of approximately 600 feet. Phases 1 and 2 will ultimately consist of approximately 90 homes, ranging in size from 2,000 to 3,200 square feet. Phase 3, known as "The Plateau at The Buttes," will consist of 61 homes. The development will also include a 1.5-mile-long nature trail and will cover about 90 acres.

Cascadia

The proposed "Cascadia" planned community encompasses 4,720 acres of land that lies on a historically glaciated upland northeast of Orting. The western and southern boundaries to the upland are formed by the Carbon River. South Prairie Creek borders the eastern side of the upland. The valley walls of these two drainages have formed steep bluffs, nearly vertical in places, along the edges of the upland. The Cascadia development has been divided into three phases. Phase 1 includes residential and employment uses, public facilities, natural open space and will encompass an area of about 1,700 acres, including 1,719 dwelling units, and provide employment for approximately 2,400 workers. Phase 2 will encompass an area of about 1,750 acres, including 3,217 dwelling units, and provide employment for approximately 6,945 people. Phase 3 plans are still in the conceptual phase (PALS, 1998).

Community Plans

Two community planning areas, Alderton-McMillin and Graham, lie within the Basin planning area. Community plans use the *Pierce County Comprehensive Plan* as a foundation and allow citizens of local communities to make specific recommendations regarding certain issues that can directly affect surface water and groundwater resources and stormwater facilities design, for example:

- Special areas needing protection,
- Needed public facilities,
- Transportation facilities,
- Community image and design features,
- Commercial buildings and large-scale housing design, and
- Certain land use patterns).

Alderton-McMillin Community Plan

The Alderton-McMillin Community planning area lies south of Sumner and northeast of Orting. An upland area west of the city of Bonney Lake is also included. A small portion of the 2,808-acre community planning area lies within the Lower Carbon River direct drainage area. The proposed Alderton-McMillin Community Plan inventories community preferences and characteristics. It recommends policies on environmental protection, economic development, transportation, building and facilities, and land use designations, and identifies action steps to be taken to reach the community's 20-year vision.

Graham Community Plan

The southeastern edge of the approximately 7,707-acre Graham Community lies within the Upper Puyallup River Basin planning area. The Graham Community is located in south central Pierce County at the fringe of the County's urban growth area. The community planning area is bounded by the communities of Spanaway, Frederickson, and South Hill to the north. State Route 7 is located along the western boundary of the planning area. 352nd Street East represents its southern boundary. The Graham community planning area extends as far east as the Puyallup River Valley. Many small, distinct communities are located within the plan area, including Graham, Elk Plain, Kapowsin, Thrift, and Rocky Ridge.

The Graham Community Plan includes two new land use designations (rural sensitive resource and rural farm) and five new zoning classifications (community employment, single-family, moderate high density residential, rural sensitive resource, and rural farm) and one zoning overlay (Thun Field Airport overlay). The community plan seeks to designate land uses that reflect a rural character and provide a stepped-down scale from the intensity and density of uses found in the more urban neighboring community plan areas of South Hill, Frederickson, and Parkland-Spanaway-Midland. As such, the community has chosen to lower the maximum urban residential densities and commercial intensities. In addition, rural residential densities have also been amended to reflect a larger lot pattern or provide increased protections for or from critical areas. Finally, agriculture is very important to citizens within the plan area, and the area designated as farm land has been significantly increased to more accurately reflect current farming and agricultural activities.

8.3 FLOOD CHARACTERISTICS

Pierce County regulates potential flood hazard areas. The “A Zone” represents a 100-year flood hazard area. The “X500 Zone” (formerly referred to as “B Zone”) represents the 500-year flood hazard area. Additional potential flood hazards include:

- **Natural Waters/Watercourse**—Areas within 65 feet horizontal distance from the ordinary high water mark of an identified natural watercourse.
- **Groundwater Flooding Areas**—Areas within 300 feet horizontal distance from a mapped groundwater flooding area.
- **Potholes**—Areas not mapped as a flood hazard area but within 10 feet of vertical relief from the bottom of an identified pothole or within 2 feet of vertical relief of a potential surface water outlet. Potholes are closed depressions with no natural surface water outlet.
- **Channel Migration Zones (CMZ)—**Areas where detailed CMZ studies have been completed and accepted by Pierce County. Channel Migration Zones are the area within which a river channel is likely to move over a period of time.

The following reaches within the Carbon River and Upper Puyallup River Basin have been studied in by FEMA using detailed methods:

- South Prairie Creek from the mouth upstream to the eastern corporate limits of South Prairie.
- Wilkeson Creek from Burlington Northern Railroad upstream for 0.3 mile to the corporate limits of Wilkeson and from the southern corporate limits of Wilkeson upstream for 0.3 mile.

Table 8-5 lists the estimated extent of the flood hazard inundation area for each subbasin by FEMA using detailed and un-detailed methods.

Pierce County has also developed mapping data for pothole flood hazard areas and CMZ flood hazard areas. One provisional pothole has been mapped in the Basin in the South Prairie Creek subbasin ("Provisional" describes the confidence in the mapped location of the pothole). A provisional pothole requires further research to obtain more detailed information on the location of the provisional pothole and the extent of the hazard. The hazard may also need major improvements to prevent future flooding.

Also, two geomorphic evaluation and CMZ studies have been performed for rivers in the Basins. These studies delineated low, moderate, and severe potential stream migration areas. One study completed in 2003 included the Puyallup and Carbon Rivers. A second study, completed in 2005, delineated a CMZ for lower South Prairie Creek. Pierce County only regulates severe potential migration areas. Channel migration zones are regulated as floodways. Construction of structures is prohibited in floodways.

TABLE 8-5
Summary of 100- and 500-Year Floodplain
in Carbon/Upper Puyallup River Basin

Subbasin Name	Total Subbasin Area (acres)	1% Annual Chance Flood Inundation Area (Acres)	Subbasin Area within 1% Annual Chance Flood Inundation Area (%)	0.2% Annual Chance Flood Inundation Area (Acres)	Subbasin Area within 0.2% Annual Chance Flood Inundation Area (%)
Coplar Creek	1.484	22	1%	26	2%
Fiske Creek	1,076	21	2%	31	3%
Fox Creek	3,294	96	3%	110	3%
Kapowsin Creek	6,800	785	12%	971	14%
Ohop Creek	9,681	439	5%	469	5%
South Prairie Creek	37,103	1,216	3%	1,318	4%
Spiketon Ditch	2,136	41	2%	56	3%
Unnamed Carbon River Tributary #1	1,434	40	3%	77	5%
Unnamed Carbon River Tributary #2	442	17	4%	40	9%
Unnamed Fiske Creek Tributary	587	0	0%	1	< 1%
Unnamed Kapowsin Tributary #1	215	< 1	< 1%	21	10%
Unnamed Kapowsin Tributary #2	1,199	112	9%	186	15%
Unnamed Voight Creek Tributary	1,435	80	6%	93	6%
Voight Creek	19,243	663	3%	703	4%
Wilkeson Creek	18,340	368	2%	446	2%
Total	104,469	3,900	4%	4,548	4%

8.3.1 Known Flood Hazards

Figure 8-1 shows the mapped floodplains within the Carbon/Mid Puyallup River Basin. The floodplain boundaries are based upon the most current mapping for Pierce County prepared by the Federal Emergency Management Agency (FEMA). The data is derived from the FEMA *Flood Insurance Rate Maps* (FIRMs).

The "A Zone" represents a 100-year flood hazard area, an area estimated to have a 1% chance of flooding in any given year, or a one-in-100 year chance.

The "X500 Zone" (formerly referred to as "B Zone") represents the 500-year flood hazard area, an area estimated to have a 0.2% chance of flooding in any given year, or an area with a high risk of flooding that has a small drainage Basin (less than one square mile).

8.3.2 Causes of Flooding

Riverine flood hazards typically arise from the Puyallup, Carbon, and South Prairie Creek Rivers. The middle and upper reaches of the Puyallup River constitute an entirely unregulated and naturally flowing river system, therefore, monitoring and forecasting rain-on-snow events is critical because of the rapidly changing Basin conditions that can occur (Pierce County Natural Hazard Mitigation Plan, 2005). However, the major source of repetitive and destructive flooding is in Clear Creek, a tributary to the Puyallup that is not considered part of the Upper Puyallup River.

Beavers are a common cause of minor flooding throughout the Basin planning area. Beaver blockages were frequently reported by Basin residents; and as many as eight of the flooding and drainage problems were directly attributed to beavers.

Flooding and drainage problems frequently involved roadway flooding. Beavers are frequently a cause of roadway flooding because they often build inside culverts to create blockages.

The following items are potential causes of future flooding or flood damages:

- Insufficient maintenance
- Beavers
- Deterioration/failure of existing facilities
- Increased flow from new impervious surfaces
- Diversion or obstruction of drainage courses due to construction
- Filling within floodplain without providing compensatory volume
- Building in floodplain or below maximum flood elevation
- Channel migration (including scour, deposition of sediments and downstream impacts of inadequate efforts to modify channel alignment)
- Undersized culverts or conveyance system

Future flooding problems are most likely to arise in areas of residential and commercial development. Although most of the planning area is rural, low-density development can still result in new flooding problems.

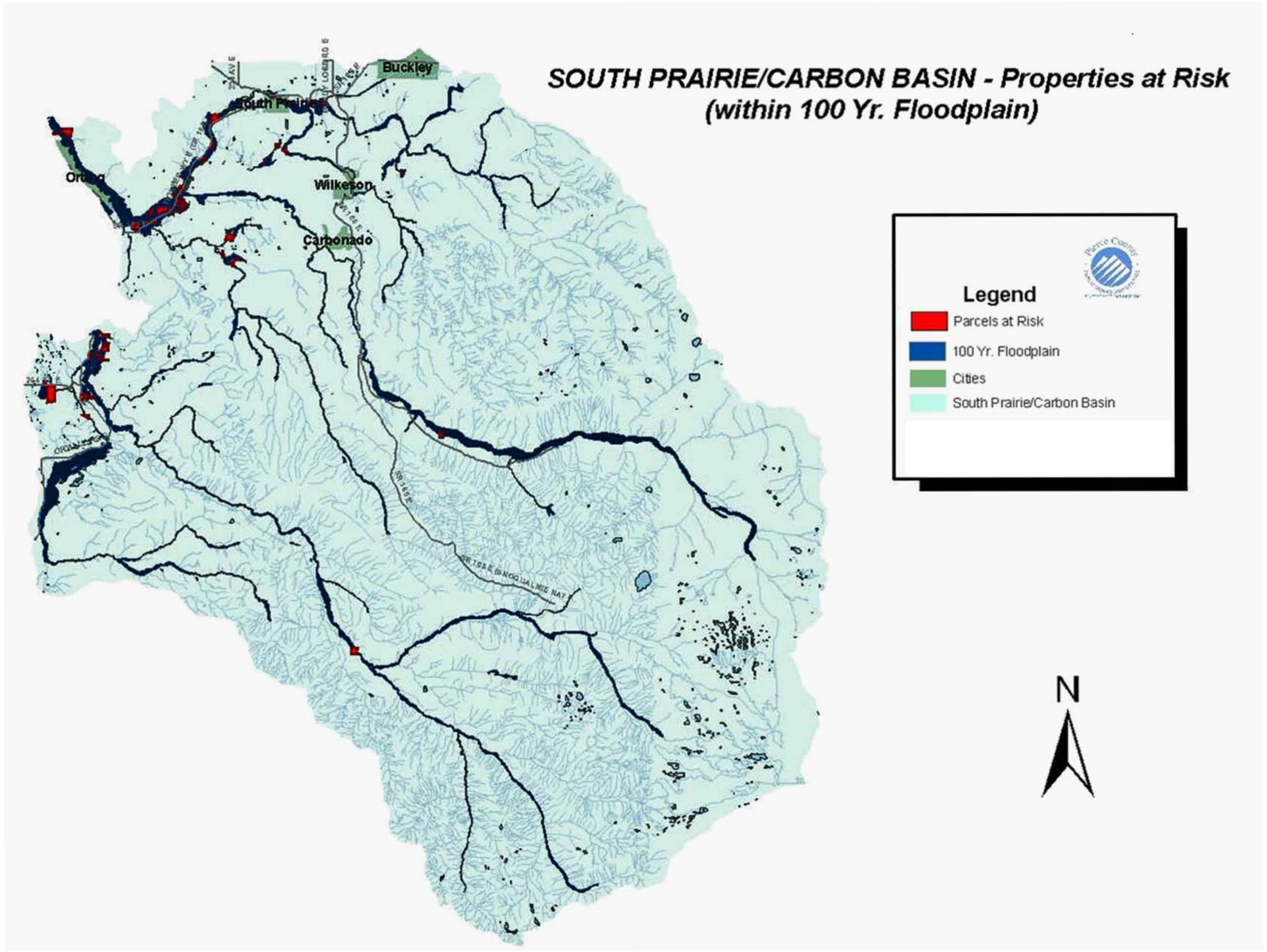

Figure 8-1
Floodplain extent and location
Carbon & Upper Puyallup Rivers Basin

8.4 FLOOD HAZARD IMPACTS

Flooding within the Carbon River or Upper Puyallup River Basins can have numerous impacts on the way of life within this Basin, and Pierce County in general. The following subsections summarize the vulnerability of public safety and health, improved property, and critical facilities within the Basins and generally assess the impact a flood would have on the Basin's population and economy.

8.4.1 Public Safety and Health

A flood in the Carbon River and Upper Puyallup River Basin would produce a variety of possible adverse impacts to life, public safety, and public health. No loss of life due to flooding has been reported within the Basin, but damage and disruption caused by flooding has been a recurrent problem.

Like Pierce County, the Basin has experienced substantial growth in recent years and is expected to support more growth into the future. According to the U.S. Census, the population of Pierce County in 2000 was 700,820. According to the Puget Sound Regional Council's (PSRC) long-range population forecasts for the forecast analysis zones within Pierce County, the County population is expected increase 16 percent to 812,859 by 2010 and reach 892,314 by 2020 (*2001 Population and Employment Forecasts* report for the central Puget Sound region, PSRC, 2002). The estimated 2000 population in the Carbon River and Upper Puyallup River planning area was 13,968, which is about 2% of the County's total population in 2000. Assuming that the planning area will continue to capture at least 2% of the county's growth, it is predicted that in 2010, the population residing in the Carbon River and Upper Puyallup River Basin planning area will be approximately 16,201 and 17,786 people will reside within the Basin in 2020.

Based on these projections the assumptions for the potential impacts of flooding are as follows:

- Increased pressure to develop floodplains within the Basin to accommodate the increasing population.
- It should be noted that the current/existing regulatory environment within Pierce County is very focused on not allowing an increase in flood risk exposure due to new development. As long as this regulatory environment remains intact, the assumption would be that development in response to this new growth would be directed away from the known flood hazard areas within this Basin.
- There is currently little warning capability within this Basin. As the population increases within this Basin, the need to enhance or create a flood warning and response system increases within the County.

The only real-time flood warning capability exists along the South Prairie Creek, within the Town of South Prairie. Three additional USGS real-time gauges are located on the main stem Puyallup and Carbon Rivers.

In the spring of 2006, Pierce County Water Programs installed six stream flow monitoring gauges within the Carbon River and Upper Puyallup River Basin. Gauges were installed on the following streams:

- Voight Creek
- Wilkeson Creek
- Fiske Creek
- Kapowsin Creek
- South Prairie Creek
- Spiketon Ditch

The locations of the gauges were selected based on accessibility, proximity to the subbasin outlet, and hydraulic conditions. Each site consists of a staff gauge, a pressure transducer (to measure depth) with an internal data logger, and a battery pack. Flow depths are measured automatically and recorded by the data logger. The data loggers are downloaded monthly.

Several manual estimates of stream discharge will be made at each stream gauging site. These discharges will then be used to develop rating curves that relate stream discharge to flow depth. The rating curves developed for each site will be used to convert the recorded flow depths into stream discharge estimates. Stream discharge hydrographs will be used to calibrate hydrologic models for future analyses.

The approximate lead time for flood warning provided within this Basin is 24 to 48 hours based on flood threat recognition system capability within the Basin. Flood prediction is not an exact science. Although gage readings and historical data are excellent forecasting tools, rivers can continually change. There are also local factors that can contribute to flooding such as stream and creek discharge into a river, snowmelt and damming caused by fallen trees and other debris. Therefore, during flood situations floodplain residents should not rely solely on gage readings and historical flood levels, but should keep an eye on the river and stay tuned to local media reports.

8.4.2 Critical Facilities

Using the parameters to define "Critical Facilities" discussed in Chapter 1 of this risk assessment, Pierce County Water Programs, coordinating with Pierce County Emergency management has identified the critical facilities listed in *Table 8-6* that could be impacted by flooding within the Carbon/Mid-Puyallup River Basin. The basis for this determination is: physical location within a mapped or known floodplain, known history of flooding, and the lack flood protection to the facility. These are facilities that are considered to be vulnerable and in need of an action(s) to mitigate the impacts of flooding. It should be noted that this list does not include critical "infrastructure".

Since the Pierce County Water Programs Division *Basin Planning Program* has such a strong capital facilities component, it has been assumed that critical infrastructure with vulnerability to flooding within each basin will be adequately addressed through the basin planning problem assessment and action prioritization process. A detailed assessment of these facilities is not provided in this risk assessment for security purposes.

Pierce County Emergency Management has performed this assessment as part of the County-wide *Hazard Mitigation Plan* prepared pursuant to the "Disaster Mitigation Act." The County will direct the "non-structural approach" by this plan. The focus of the Basin Planning Program as it pertains to critical facilities will be to attempt to provide flood protection to potentially vulnerable critical facilities through the structural approached identified as actions. Both programs consider it a high priority to provide protection to critical facilities, and are committed to working together to achieve this objective.

TABLE 8-6
CARBON/UPPER-PUYALLUP RIVER BASIN CRITICAL FACILITIES IN THE 100-YEAR FLOODPLAIN

Government Function	Hazardous Materials	Schools	Other	**Total**
0	0	1	0	**1**

8.4.3 Structures Impacted

A series of GIS spatial queries were performed to estimate the numbers of structures that are at risk to flooding. An at-risk structure was identified for each tax parcel in which the centroid of the tax parcel was within a flood inundation area (1 percent annual chance). If the centroid was outside the tax parcel, a point within the parcel was used. Only parcels with an appraised value of greater than $25,000 were assumed to have a structure.

To identify the potential dollar/loss exposure for the basing, assessed values for improvements to each of the parcels shown to have structures within the 100-year floodplain were accumulated by subbasin. This value is representative of the exposure. To truly gauge vulnerability, the depth of flooding would need to be identified to apply FEMA's depth/damage functions to this exposure. This detail of information was not available at the time of the preparation of this assessment. However, total exposure values can be a good gauge of potential flood impact for planning purposes and for identifying potential project benefits when prioritizing mitigation actions.

Table 8-7 lists the total number of structures within the 1% annual chance flood inundation area by structure type and the market improvement value of the exposure.

8.4.4 Repetitive Loss Areas

As required by section 503.c, of the *2006 CRS Coordinators Manual*, Pierce County has created a list of properties considered to be in a repetitive loss area, as defined under section 503.b. Pierce County considers 100% of its regulated floodplain to be subject to repetitive flood risk exposure. This premise is the basis for its comprehensive floodplain management program. None of the identified repetitive loss areas lie within the Carbon River or Upper Puyallup River Basin.

8.4.5 Insurance Analysis

Flood insurance statistics can help identify vulnerability by regionally isolating areas where claim activity is high and a high rate of flood insurance is in force. *Table 8-8* summarizes vital insurance statistics that can be used to help identify vulnerability within the Carbon River and Upper Puyallup River Basin. The locations of properties covered by these policies are shown in *Figure 1-2*.

Based on a review of this data, the following observations can be made:

- Based on the approximate number of primary, insurable structures in the floodplain and the insurance coverage in force within the floodplain, insurance coverage as a form of mitigation appears to be well below the national average. According to a study being conducted for the NFIP by the Rand Corporation nationwide, about 49% of single-family homes in special flood hazard areas (SFHAs) are covered by flood insurance.
- With 54.5% of the current policies in force located outside of a mapped floodplain, there appears to be some flooding issues within this Basin not addressed via the existing mapping. These could be drainage related flood issues that the Basin Planning program seeks out, that typically are not captured through standardized floodplain mapping techniques.
- There is a moderate level building exposure within this Basin, which explains the low policy count, yet higher rate of coverage. This suggests that there has been wise land use within the Basin, which should be continued as growth pressures increase within the Basin.

TABLE 8-7
STRUCTURES IN THE 100-YEAR FLOODPLAIN; CARBON/UPPER PUYALLUP RIVER BASIN

Subbasin	Structure Type				Market Improvement Value
	Commercial	Dwelling	Other	**Total**	
Coplar Creek	0	1	0	**1**	$104,906
Fiske Creek	0	1	0	**1**	$104,906
Fox Creek	0	0	0	**0**	$0
Kapowsin Creek	0	6	2	**8**	$771,398
Ohop Creek	0	0	0	**0**	$0
South Prairie Creek	0	34	5	**39**	$3,921,709
Spiketon Ditch	0	0	0	**0**	$0
Unnamed Carbon River Tributary #1	0	0	0	**0**	$0
Unnamed Carbon River Tributary #2	0	2	0	**2**	$209,812
Unnamed Fiske Creek Tributary	0	0	0	**0**	$0
Unnamed Kapowsin Tributary #1	0	0	0	**0**	$0
Unnamed Kapowsin Tributary #2	0	3	0	**3**	$314,718
Unnamed Voight Creek Tributary	0	3	1	**4**	$385,699
Voight Creek	0	22	2	**24**	$2,449,894
Wilkeson Creek	0	8	1	**9**	$910,229
Total	**0**	**80**	**11**	**91**	**$9,173,271**

TABLE 8-8
FLOOD INSURANCE STATISTICS FOR THE CARBON/UPPER PUYALLUP RIVER BASIN

Number of flood insurance policies in force within the Basin (as of May 1, 2007)	109
Number of Policies within a mapped floodplain (FIRM)	50
Number of Policies outside of a mapped floodplain	59
Number of Claims filed within the Basin	8
Number of claims filed for losses outside the 100-year floodplain	5
Estimated number of insurable, primary Structures in mapped floodplains	80
Estimated % of at risk structures with flood insurance coverage	62.5%
% of current flood insurance coverage outside of a mapped floodplain	54%