CHAPTER 4

STUDY AREA CHARACTERISTICS

This Stormwater Master Plan (SWMP) is based on the physical and social characteristics of the study area. These characteristics include land use, topography, geology, soils, climate, and the natural streams and manmade pipe and channel systems that comprise the overall conveyance system. Each characteristic to some degree influences the quantity and quality of stormwater runoff and the health of the watershed. This chapter presents the characteristics used as the basis for developing the SWMP. In addition, this chapter describes the general impacts of urbanization on a watershed.

4.1 GENERAL DESCRIPTION OF THE STUDY AREA

This section describes the physical and social characteristics that influence the quantity and quality of stormwater runoff within the study area shown in Figure 4-1. The description focuses on the area within the City, although the overall planning effort includes the watersheds in their entirety. A general description of the area outside of the city limits is presented in Section 4.3.

4.1.1 Land Use

The City of Corvallis (City) is the county seat of Benton County, Oregon. It lies near the middle of the Willamette Valley, home to over two-thirds of Oregon's population and the majority of its industries. Corvallis is well connected by transportation lines to the rest of the Willamette Valley. Oregon State Highways 34 and 20 provide east-west access and Highway 99 runs north to south. United States Interstate 5 is located about 11 miles to the east. A railroad line operated by the Willamette and Pacific Railroad also serves Corvallis, as does the municipal airport located south of the City.

Benton County was settled in the mid-1800s with statistics listing a population of 3,065 in 1860. The population has increased about 30 percent every 10 years since 1900, although the two decades following World War II saw a growth rate nearly double the long-term average. Benton County's present-day population totals over 76,000, nearly 51,000 of which live in Corvallis.

Table 4-1 lists the population increases of several nearby cities and towns. Albany and Philomath had large increases in population during the 1990s, while Benton County, including Adair Village and Corvallis, lagged behind the state average. The increase in population has caused changes in the way land is used in the area and more changes are likely in the future.

Table 4-1. Recent Area Populations

	1980	1990	1997	1998	Percent increase (1990 to 1998)
Oregon	2,633,105	2,842,321	3,217,000	3,267,550	15
Benton County (including Corvallis)	68,211	70,811	76,700	76,600	8
Corvallis	40,843	44,757	51,145	49,630	11
Adair Village	NA	554	570	570	3
Albany	NA	29,540	37,830	38,925	32
Philomath	NA	2,983	3,380	3,770	26

Source: Portland State University – Population Research Center
Note: NA – not available

The most prevalent existing land use, based on 1998 City tax lot information, is low-density residential, followed by Oregon State property as listed in Table 4-2. Unzoned land use includes areas not classified by existing land use categories, such as city streets. The projected future land uses shown in Figure 4-2 represent large declines in vacant and agricultural categories. The future scenario includes large increases for commercial, industrial, residential, and open space-conservation categories.

Table 4-2. Land Use within the Urban Growth Boundary in Acres

Hydrologic land use category	Currently developed [1]	Future planned [2]
Residential – low	4,199	6,477
Institutional (schools, OSU)	2,639	2,446
Open Space – agricultural	2,137	850
Industrial	1,030	2,000
Residential – med/high & medium	863	1,261
Residential – high	559	879
Commercial	180	560
Research/technology	0	111
Open Space – conservation	0	1,863
Vacant	4,431	0
Unzoned	1,969	1,561
Total area	18,008	18,008

[1] From existing tax lot information.
[2] From Corvallis Comprehensive Plan, 1998

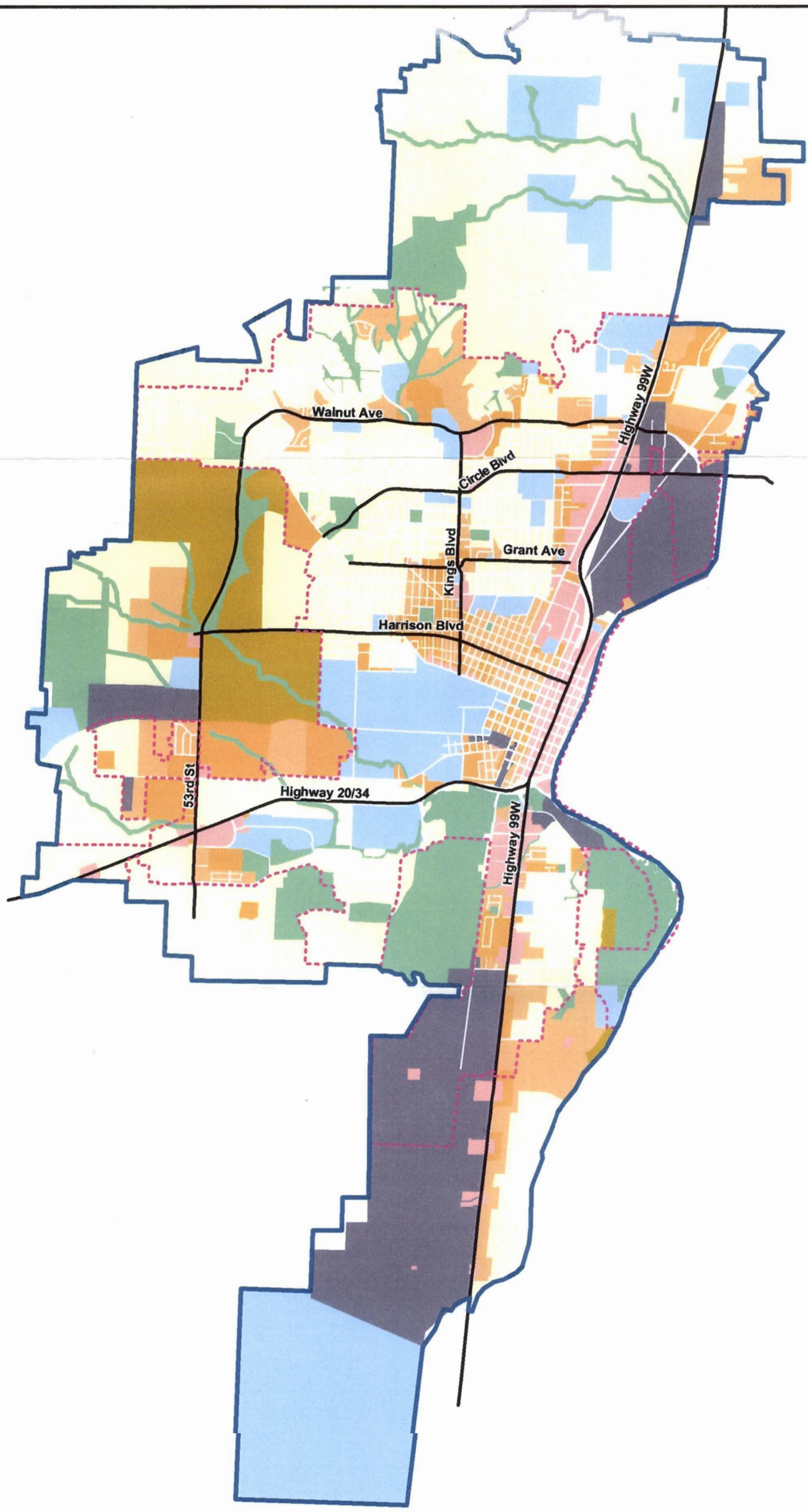


Figure 4-2 Projected Future Land Use

LEGEND

Urban Growth Boundary

City Limits

Projected Future Land Use
(from City of Corvallis Planning Dept)

- Commercial
- Industrial
- Agricultural
- Forest
- University/Institutional
- High Residential
- Low Residential
- Medium Residential

N

Mile 1/4 0 1/4 1/2 3/4 1 Mile

CORVALLIS
ENHANCING COMMUNITY LIVABILITY

Public Works Department

BROWN AND CALDWELL
and Associated Firms

report/figures/final/Fig4-2.wor, November 3, 2000, base data from City of Corvallis GIS Department

New houses, roads, parking lots, and commercial buildings have added to the impervious surface areas within the study boundary. Impervious surfaces do not allow water to infiltrate into the ground as it usually does in undeveloped areas. This causes an increase in the volume and speed of runoff. Table 4-3 shows the imperviousness percentages by land use category.

Table 4-3. Impervious Percentage by Land Use

Land Use Category	Imperviousness (%)
Commercial – high	90
Commercial – medium	87
Research/technology	76
Institutional (schools, OSU)	70
Residential – high	63
Industrial	60
Residential – medium	50
Residential – low	40
Open Space – agricultural	15
Vacant	10
Open Space – conservation	5

The imperviousness percentages were calculated based on the City's photogrammetric maps that show buildings, streets, and sidewalks. Commercial areas have the highest imperviousness percent, followed by research/technology, and institutional areas. For the purposes of this study, the unzoned areas listed in Table 4-2 were distributed proportionally into the other land uses shown in Table 4-3. Commercial land use includes both the downtown core area and shopping centers/commercial strips, such as those along 9th Street and Kings Boulevard. The imperviousness percentage of industrial areas in Corvallis is less than what is typically assumed for cities this size, because of the campus nature of several industrial developments. The Hewlett-Packard facility is an example of this type of development. Current land use policy encourages the preservation of significant natural resources, further reducing the impervious cover in the developed areas. The City also encourages increased density and compact development, which is likely to have the opposite effect and increase the impervious cover. It is anticipated that the net result of impervious cover will be similar to what it is today.

Land use not only influences the quantity of stormwater runoff, but also the quality of the runoff. Areas of high imperviousness, such as industrial areas and streets, can have some of the highest pollutant loads, and open spaces the lowest. Information on the pollutant loads associated with various land uses is listed in Table 4-5.

4.1.2 Topography

Topography affects many of the characteristics of stormwater runoff. Hilltops, ridgelines, and other high points determine drainage basin boundaries. Ground slope influences the amount and velocity of runoff. Steeper slopes drain easily, but are prone to erosion. Flat areas experience greater flooding and often have sediment deposits. Topography can also limit the type of stormwater facilities that can be sited within a given area and their effectiveness.

Corvallis is located at the junction of the Willamette and Marys Rivers. Marys River splits the City into northern and southern sections. The southern section includes the floodplain of the Willamette River. The northern section contains three topographic regions: the floodplain of the Willamette River, the Willamette Valley floor, and the foothills of the Coast Range. The Willamette River also forms the eastern boundary of the City. The Willamette River floodplain lies in the northeast and southern part of the study area, with elevations that are subject to frequent flooding.

The Willamette Valley floor makes up most of the study area. Elevations range from 220 feet at the Willamette River to 480 feet at Witham Hill. The slopes of most conveyance facilities within this region are relatively flat and follow the terrain.

The foothills of the Coast Range lie west of 53rd Street and north of Walnut Boulevard. Most of the City's northern streams originate in the foothills outside the city limits. Ground slopes are moderately steep and elevations range up to 2,000 feet to the northwest.

The study area drains to the Willamette and Marys Rivers through a number of distinct watersheds. The watersheds are defined by the topography and by manmade structures, such as streets, that influence the direction of stormwater runoff. Six watersheds lie in the northern part of the study area:

- Dixon Creek
- Squaw Creek
- Jackson/Frazier/Village Green Creeks
- Sequoia Creek
- Garfield Basin
- Oak Creek

The southern part of the study area contains two watersheds:

- Marys River
- South Corvallis

4.1.3 Geology

Although this SWMP primarily addresses the impacts to the conveyance systems due to 150 years of human development, the effects of millions of years of geological processes continue to play an important role. The rock formations and soils of the area influence stormwater runoff rates, the rate of infiltration, and the elevation of the water table.

Parent materials in the Corvallis area originate from two primary sources: sedimentary deposits, and volcanic action. Some 40 to 60 million years ago, all of western Oregon was covered by a shallow sea in which thousands of feet of sediment accumulated. Volcanoes and uplifting of the land nearly 15 million years ago formed the Cascade and Coast Range Mountains. The Willamette Valley was formed and began to function as the main drainageway for transporting runoff and sediments eroded from the mountains (alluvium). Most of the soils in the study area are formed from terraces resulting from the sand and gravel alluvium deposited in the Willamette River Valley. The soils are relatively deep along the valley floor, but can be quite shallow in the steeper areas with only 1 to 4 feet of soil over bedrock. The depth to impermeable layers of rock and soil helps determine groundwater depths and influences infiltration rates.

Early development in Corvallis was generally restricted to the flatter, terraced areas, not far from the Willamette River. As the City grew, development expanded to the surrounding hills. In the future, additional development will occur on the steep hillsides to the north and west. These areas represent a potential for high velocity runoff that can erode the ground surface, particularly from construction sites, and erode and down-cut natural channels. In addition, development on steep slopes must maintain slope stability. Modifications to the natural drainage system can affect the potential for slope failures.

4.1.4 Soils

In addition to topography and impervious surfaces, soil type is another determinant of runoff volumes. The parent material, sediment grain size, saturation, and organic content are just a few of the factors that influence runoff rates and volumes. The Soil Conservation Service, now known as the Natural Resources Conservation Service (NRCS), investigated all soil factors, classified the soils and their areal extent, and categorized them as to suitability for farming, building, and recreation. More important to this study, however, is the soil classification into hydrologic groups based on the soil's engineering properties. Hydrologic groups can be used to estimate the total volume and peak runoff expected from storms.

Soils are grouped into four hydrologic categories: A, B, C, and D. Group A soils are coarsely textured and allow rapid infiltration of precipitation. Groups B, C, and D are increasingly finer-textured soils with correspondingly slower infiltration rates. Group D soils have the slowest infiltration rates and are associated with a high groundwater table, little depth to bedrock, and other factors that increase runoff.

The NRCS has classified Corvallis soils into four main soil associations as shown in Figure 4-3. Along the rivers and stream banks, the group D, poorly drained clay soils of the Waldo-Bashaw association predominate. Most of the valley floor contains silt loams of either the poorly-drained Dayton-Amity association (groups D and C, respectively) or the moderately well-drained Woodburn-Willamette association (groups C and D, respectively). Finally, in the headwaters of the northern streams, the Dixonville-Philomath association (groups C and D, respectively) of well-drained silty clay loams are found. The generally low infiltration rates and rapid runoff of Corvallis soils limits the use of stormwater management strategies that depend on infiltration.

4.1.5 Climate

The Corvallis area, like the rest of the Willamette Valley, has a maritime climate, which results in mild temperatures and ample rain, most of which falls in the winter months. Table 4-4 lists the most recent 30-year average for Hyslop Field, an experimental field station that Oregon State University maintains northeast of Corvallis.

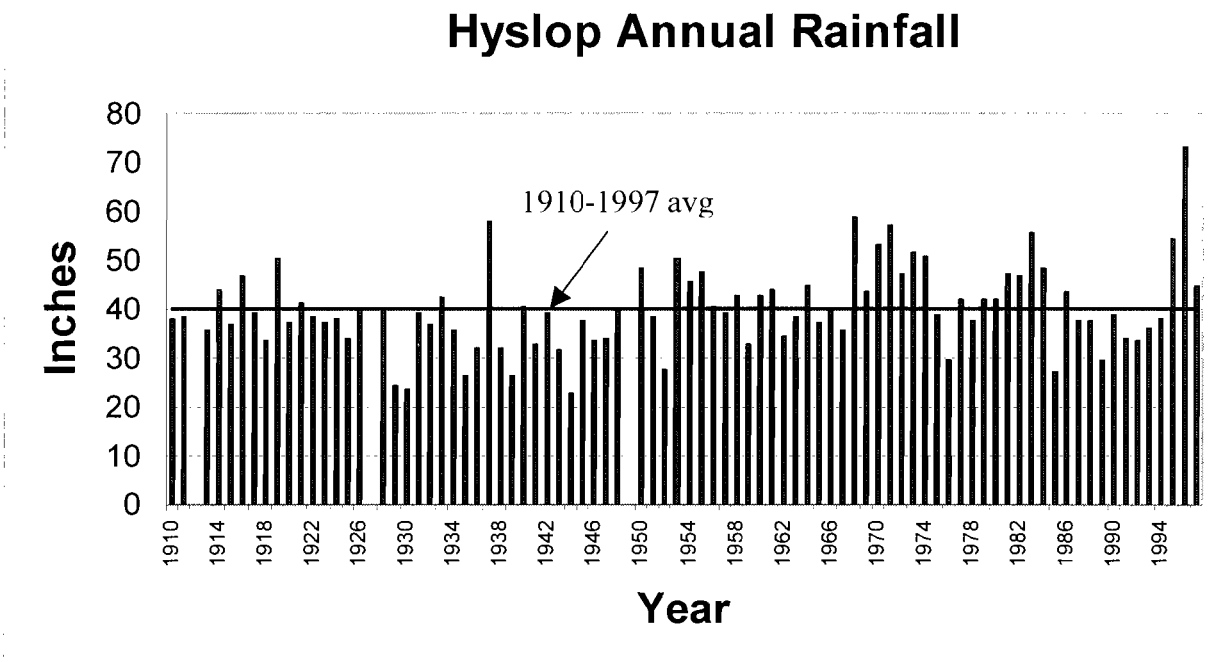
Table 4-4. Climate Statistics for Hyslop Field (1961-1990)

	Temperature (deg F)			Precipitation (inches)	
	Mean	Max	Min	Mean	Maximum (24hr)
Jan	39.3	45.5	33.0	6.82	4.28
Feb	42.7	50.4	35.1	5.04	2.76
Mar	46.0	54.9	37.0	4.55	1.90
Apr	49.3	59.5	39.2	2.56	1.83
May	54.6	66.1	43.1	1.95	1.58
Jun	60.9	73.1	48.6	1.23	1.33
Jul	65.6	80.2	51.0	0.52	1.26
Aug	66.2	81.1	51.3	0.87	1.48
Sep	61.6	75.4	47.8	1.51	2.18
Oct	53.0	64.3	41.7	3.11	1.81
Nov	45.1	52.3	38.0	6.82	2.68
Dec	39.7	45.6	33.9	7.72	2.87
Annual	52.0	62.4	41.6	42.70	

Source: Oregon State University

Due to the cyclic nature of climate, a 30-year record is not a sufficient length of time for planning and design purposes. Figure 4-4 shows annual rainfall in an 87-year span and depicts cyclical patterns in the Corvallis area. The drought of the 1930s is plainly apparent in the graph, as are the wet years from 1968 to 1974. More recently, the years from 1987 to 1994 all show below-average rainfall, while 1995 to 1998 show above-average rainfall.

Figure 4-4. Annual Rainfall at Hyslop Experimental Field

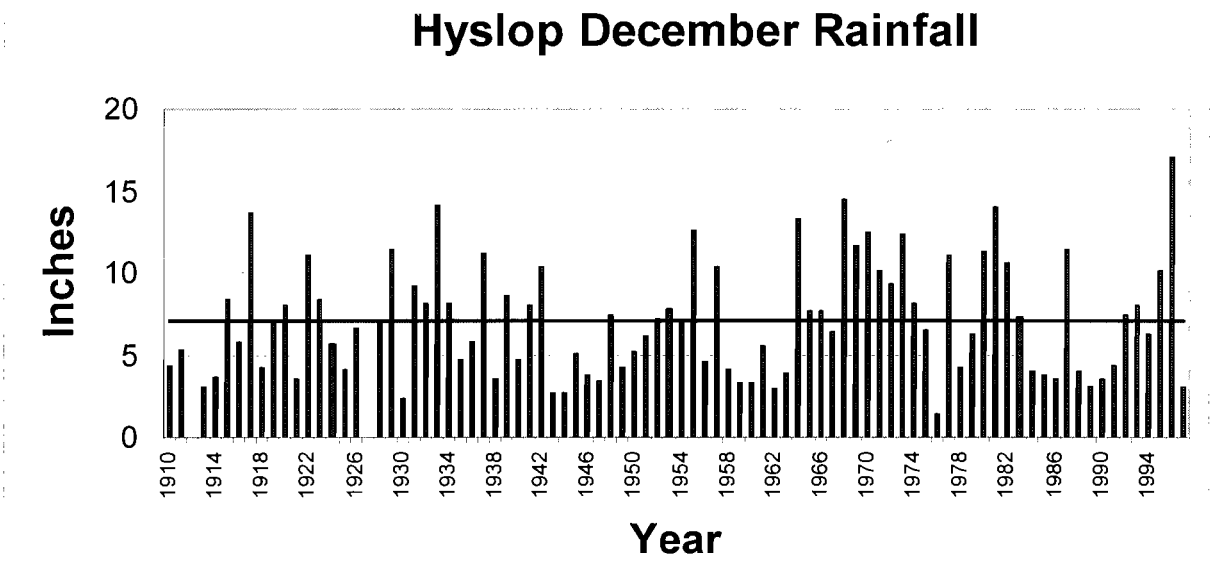


These long-term trends generally coincide with river and stream flows. However, short-term variations in the weather also play a significant role. For instance, in 1964 (the year of a severe flood event), the annual rainfall was 44.7 inches, only slightly above the long-term average of 40.1 inches. Figure 4-5 shows rainfall for the month of December over the same span of years as in Figure 4-4. A comparison of the monthly record shows that the December 1964 rainfall (13.27 inches) was nearly twice the long-term average for December (7.07 inches). Marys River had a 50-year flood event on December 22, 1964. These large deviations from average annual and monthly values must be considered during the stormwater planning process.

In addition to variations over time, annual rainfall varies spatially. The 30-year average is 42 inches on the valley floor and about 50 inches in the Oak Creek headwaters. Measurable precipitation (0.01 inches or more) occurs more than 150 days a year on average on the valley floor. Over 70 percent of the precipitation occurs from November through March. The vast majority falls as rain—only about 8 inches of snow is seen annually.

The hottest month in Corvallis is July with average temperatures of 69.8 degrees F. February is the coldest month with a 42.1 degrees F average. February has the lowest average soil temperatures, 38.6 degrees F, although extremes may reach below freezing for brief periods.

Figure 4-5. December Rainfall at Hyslop Experimental Field



4.1.6 Habitat and Vegetation

Prior to European settlement, many of the rivers and creeks of the Willamette Valley had broad, braided channels. Forests of alder, big leaf maple, black cottonwood, Oregon ash, and willow formed riparian corridors 1 mile or wider in many places. The land outside the corridors was kept open through seasonal burning by the native Kalapuya people. Due to high winter rainfall and impermeable clay soils, seasonally wet prairie occupied much of the open areas. Common camas, a wet prairie forb, was a major food source of the Kalapuya. Tufted hairgrass was also common in the wet prairies, along with many other grasses, sedges, forbs, and shrubs. On higher ground and along seasonal drainages, fire-tolerant trees such as Oregon white oak and Douglas fir grew in forests and open savannas, along with grand fir, ponderosa pine, and Pacific Madrone.

The natural habitat within the study area is influenced by the maritime climate, the topography, and the soil type (predominantly clay). The resulting natural habitat is oak and Douglas fir forests in the upland areas, and cottonwood, ash, and willow thickets along the numerous riparian corridors. The natural habitat has been heavily impacted by human activities, beginning with farming in the mid-1800s. This impact has dramatically increased with post-World War II urbanization. Some of the most obvious changes have been in the hydrologic cycles and vegetation of the study area. Today, the narrow, discontinuous strips of vegetation remaining along most of the City's streams provide limited habitat value.

Urban land use has greatly altered riparian vegetation in Corvallis. Stream confinement and channelization have resulted in higher than normal rates of downcutting in many areas, hydraulically disconnecting the streams from their floodplains and leaving riparian vegetation high and dry. Excessive erosion and sediment deposition resulting from downcutting and other human disturbances

also harm riparian vegetation. Other stresses include pollution and habitat fragmentation. These stresses have made the native plant communities especially vulnerable to colonization by invasive and/or exotic species. Himalayan blackberry and reed canarygrass have taken over many riparian areas in Corvallis, growing as virtual monocultures and displacing more diverse, native plant communities.

The development of vacant land not only increases the amount of impervious area, but also decreases the storage provided by vegetation that intercepts precipitation before it reaches the ground. Stands of conifers intercept the most precipitation, at an estimated 28 percent. The interception rate for deciduous trees is 13 percent, which is similar to grasses at 10 to 20 percent (USDA, 1998). Vegetation also increases the available water-holding capacity (AWHC) of the soil via macropores within plant roots. The AWHC of soils covered with an impervious surface is assumed to be negligible or 1 millimeter (mm); grass and shrubs provide 103 mm in silty clays; mature forests provide 175 mm (Ferguson, 1994). Both the interception and AWHC factors are much more significant during dry, summer, weather conditions than during winter when saturated soils are more common.

Urban development has large impacts on natural resources and habitat. Throughout the watershed, the reduction in trees and shrubs in favor of lawns decreases available food and nesting sites. When food and nesting sites are still available, the fragmentation of habitat may prevent travel between them and water sources. Application of pesticides, collisions between animals and vehicles, and predation by domestic pets also increase with urbanization in the watershed. Within the stream corridor itself, increased flows from more impervious areas may cause erosion of stream banks or resuspension of deposited sediments. Rapid runoff means less infiltration to replenish groundwater, leading to lower natural-base stream flows during summer. This is offset by summer irrigation and runoff in developed areas that contribute to base stream flows. Removal of trees can lead to increased stream temperatures, which decreases dissolved oxygen in the water. All of these potential effects of development reduce habitat value.

The recent Endangered Species Act listing of Chinook salmon and steelhead for the Upper Willamette River has brought habitat concerns to the forefront of watershed planning in the area. The listing will likely affect development and other construction- and maintenance-related activities in the Corvallis area. Work within the streams may be subjected to more scrutiny. Proposed alternatives for addressing stormwater-related deficiencies need to be "fish-friendly," such as culverts that allow fish passage.

4.1.7 Fisheries and Wildlife

Corvallis streams support a diversity of fish species. Many species are native and, although they serve important roles in stream ecology, they often go unnoticed. Native fish include northern pikeminnow, largescale sucker, peamouth, sculpin, dace, chiselmouth, and whitefish. Other species such as largemouth bass, smallmouth bass, and bluegill have been introduced and, although popular among anglers, can compete with or prey upon native fish. These are collectively referred to as "warm water" fish and their distribution in the Corvallis area is limited to the lower gradient or valley floor reaches of streams approaching a confluence with the Marys or Willamette Rivers.

Of greatest concern are species sensitive to habitat change or whose numbers have already declined from historic levels. Oregon chub, a small minnow-like fish once common to backwaters and sloughs along the Marys and Willamette Rivers, is now federally listed as endangered. Although no existing population of chub has been documented in Corvallis, this area is within the species' historical range and a small population does currently exist in Muddy Creek, a tributary of the Marys River, which is a short distance upstream from Corvallis.

The decline of salmonids is more widely recognized in Oregon and the Willamette Basin. Over the past few decades, several species of salmon, trout, and steelhead have been found in this area. Those native to this area are spring Chinook salmon, cutthroat trout, and rainbow trout. Winter steelhead is also native to the upper Willamette, but the nearest basins in which they are found are the Luckiamute and Calapooia. Other salmonids, such as summer steelhead, fall Chinook salmon, and Coho salmon, were introduced by hatchery programs.

Upper Willamette spring Chinook salmon, currently listed as threatened under the federal Endangered Species Act, also use Corvallis streams for rearing juveniles. Adult spring Chinook migrate through the Willamette River past Corvallis on their way to Cascade Range river basins such as the McKenzie River, where they spawn. Juvenile Chinook, however, can migrate downstream early in their lives and are commonly found throughout the year in the Willamette River. As flows increase during the fall, winter, and spring, juvenile salmon will migrate into the Willamette River's tributaries, including those in the Corvallis area, seeking refuge or better rearing conditions.

All Corvallis-area streams support native cutthroat trout. Willamette cutthroat trout are not currently listed as threatened or endangered by the State or federal government, but are considered a "stock of concern" by the Oregon Department of Fish and Wildlife because of habitat loss. Resident trout populations are found in streams where the year-round water quality is capable of supporting their cool-water needs. These are generally confined to the upper reaches of Oak Creek, Dixon Creek, or the Jackson/Frazier basin. All streams, however, support fluvial populations of cutthroat trout on a seasonal basis. Fluvial cutthroat trout migrate between the Willamette River and its tributaries. Adults use the higher gradient reaches of area streams for spawning. The juvenile fish use the entire lengths of these systems for seasonal rearing, typically occurring in greatest numbers during the fall, winter, and spring, when the water quality can support them.

The Corvallis watersheds support an array of animals. Examples of large animals that can be found within the upper reaches of the watersheds include black bear, elk, and deer. Examples of smaller animals that are typically found within the lower reaches or streamsides include cougars, coyotes, beavers, mink, and otter. A variety of birds can be found throughout the area, with the majority of migratory species preferring the lowlands and floodplains.

4.1.8 Stormwater Conveyance System

Most of Corvallis has a stormwater conveyance system that is separate from the sanitary sewer system. Stormwater flows via pipes or over land into the nearest stream, which then flows into either the Willamette or Marys Rivers. The exception to this is the older, downtown area. Here, both stormwater and sanitary flows are carried by the same pipes in what is called a combined sewer system. During typical rainfall events, the stormwater runoff and sanitary wastes are conveyed to the Wastewater Reclamation Plant for treatment before discharging into the Willamette River. During

extreme rainfall events, some of the combined flows may discharge directly to the river, causing pollution problems. The City has made improvements to the combined sewer system, virtually eliminating the potential for untreated sanitary flows to reach the river. The improvements were fully implemented as of December 31, 2000.

4.1.9 Existing Effects of Urbanization

Many of the observed stream conditions in Corvallis are typical for an urban environment that contains large amounts of impervious areas. Studies of urbanization have shown dramatic increases in the peak flows and volumes of runoff generated from increased impervious areas. Flood levels and the rate of erosion increase in conjunction with urbanization. Channels become deeper and are no longer connected to their floodplain. There is less variety in stream conditions, which results in decreased habitat value for fish and wildlife.

A number of studies in the Puget Sound area have found that stream ecosystem impairment begins at about 10 percent imperviousness (Booth and Jackson, 1997; May et al., unpublished; Horner et al., 1996). It has been estimated that typical suburban development in the Pacific Northwest has 90 percent less storage capacity than the trees and soil of the coniferous forest (Wigmosta et al., 1994). Stormwater best management practices have the potential to recover only about 25 percent of this lost capacity (Barker et al., 1991).

Loads of sediment, petroleum hydrocarbons, metals, nutrients and other pollutants are also higher in developed areas. This further decreases the natural habitat value of the streams and riparian areas.

4.1.9.1 Drainage and Flood Issues

Corvallis has a long history of flooding. The largest flood recorded occurred between November 28 and December 4, 1861. During this nearly continuous storm activity, rainfall and abnormally low temperatures led to saturated soils and a large snow pack. When a large storm system with warmer temperatures began on November 28, the rain and melting snow led to an estimated river elevation of 32.4 feet at Corvallis, which would have flooded most of the downtown area. Other large flood events of February 1890 and December 1964 echoed the pattern of saturated soils and abnormally low temperatures followed by a warm front with heavy rain. The event of February 1996 also followed this pattern and caused widespread flooding in the Corvallis area, although dams built along the Willamette River during the 1960s and 1970s kept damage from being even greater.

Flooding from the Willamette and Marys Rivers will continue to be an issue when climatological conditions occur that are similar to those above. This type of flooding is difficult to prevent. However, other recent flooding events have been caused by high stream flows, not from the backwater effects of the Willamette and Marys Rivers. These include flooding near Arthur Circle, Lancaster Avenue, and Knollbrook Place in February 1996, November 1996, and December 1998, respectively.

City staff has noted roads that were flooded during the February 1996 storm. Flooding occurred in several parts of the City, except the northwest hills. Flooding locations have been noted in Chapters 6 through 13 for the individual basins.

4.1.9.2 Water Quality

Development within a watershed can contribute to water quality problems. Pollutants are carried by stormwater from upland areas into receiving waters. Increased flows within the conveyance system may cause erosion of stream banks or resuspension of deposited sediments. Removal of trees leads to increased stream temperatures, which decreases dissolved oxygen in the water. All of these water quality effects reduce habitat value and may even pose human health risks.

Water quality information is limited within the study area. The City performs monthly testing for *E.Coli*, pH, and dissolved oxygen in order to detect sources of pollution to Corvallis streams. The City assembles this data into an annual report made available to the public. No monitoring is done for chemicals that regulators consider priority pollutants, such as metals or nutrients. Data from other sources must be used to extrapolate the potential for water quality problems in the area.

Table 4-5 lists compiled information on pollutant concentrations in stormwater runoff from Willamette Valley monitoring sites. The information indicates that pollutants are lowest in open, undeveloped areas and highest in places with large impervious areas and elevated levels of vehicular traffic. The pollutant concentration for a given land use would be multiplied by the runoff volume from that land use to calculate the mass load of pollutants entering the conveyance system.

Table 4-5. Water Quality in Runoff from Willamette Valley Sites (mg/L)

Land use	Total suspended solids	Total phosphorus	Total copper	Total zinc
Industrial	194	0.633	0.053	0.629
Transportation	169	0.376	0.035	0.236
Commercial	92	0.391	0.032	0.168
Residential	64	0.365	0.014	0.108
Open	58	0.166	0.004	0.025

Source: Association of Clean Water Agencies, 1997

Land uses highest in pollutant concentrations also tend to be highest in imperviousness, and thus, runoff. They have a disproportionate impact, per acre, on water quality. Concentrating pollutant reduction efforts to commercial, industrial, and institutional users often gives the greatest pollutant reduction per dollar spent. However, other land uses cannot be ignored because they often cover greater areas. Future residential land use is projected to cover roughly four times the area projected for industrial use. Also, construction sites can be a major source of total suspended solids.

4.1.9.3 Erosion and Sedimentation

Erosion and sedimentation are naturally occurring processes that are unnaturally accelerated by land development. Soils denuded of vegetation and the resultant increased imperviousness are two potential effects of development that contribute to greater peak flows, longer duration of high flows, and other factors that increase erosion. Eroded material is often deposited downstream where it decreases culvert and channel capacity and smothers natural habitat.

The risks of erosion are highest in areas with fine soils, on steep slopes, and areas undergoing active construction activities. Several areas in Corvallis meet this definition, especially to the west and northwest.

4.2 STORMWATER PLANNING WATERSHEDS

This section briefly describes the physical characteristics of each of the major drainage basins. Chapters 6 through 13 provide a more detailed account of the hydrologic/hydraulic modeling results and the recommended projects and management procedures for addressing the deficiencies within each watershed.

4.2.1 Dixon Creek

The main drainage of this 2,712-acre watershed is through Dixon Creek. The North Fork originates in the hills near Chip Ross Park and the South Fork originates on Dimple Hill. The two branches join near 29th Street. From there, Dixon Creek runs about 2.6 miles and empties into the Willamette River near the Corvallis Wastewater Reclamation Plant.

Most of the watershed has already been developed with predominantly residential land use above 9th Street and commercial land use below. The open areas are located mainly in the upper reaches of the watershed, and are currently undergoing development. Future land use shows complete development of the upper reaches of the watershed to low-density, single-family residential.

4.2.2 Squaw Creek

Squaw Creek has two main branches, both over 2.5 miles long. The northern branch, originating at Bald Hill Park, and the western branch, originating near the junction of West Hills Road and Reservoir Avenue, come together just upstream of 35th Street, after which they flow less than 1 mile to their junction with the Marys River.

The creek drains almost 2,400 acres of relatively flat land. The flat topography has resulted in a number of wooded wetlands along the creek. Some of these have been preserved as part of the open areas of Starker Arts Park and the Sunset Park ball fields. The eastern part of the watershed has been developed as low-density residential. The western part is now being developed to a higher density residential.

4.2.3 Jackson/Frazier/Village Green Creeks

The Jackson, Frazier, and Village Green creeks form a complex network of streams and wetlands to the north of the Corvallis city limits. Jackson and Frazier creeks both originate in McDonald State Forest. The two flow eastward through the state forest before merging at Highway 99. East of Highway 99 their combined flow enters the Jackson-Frazier Wetland, an important habitat area. The flow leaving the wetland is split between the farmlands to the northeast and Village Green Creek to the south. Village Green Creek runs over half a mile to the southeast before joining Sequoia Creek.

The Jackson Creek portion of the watershed contains over 1,500 acres, and the Frazier Creek portion contains over 2,200 acres. Both creeks are located in largely rural areas, with forests in their upper reaches giving way to agricultural fields in the lower, flatter portions. Development has been limited mainly to housing along a number of the stream reaches. Roughly two-thirds of the 380 acres that drain to Village Green Creek are developed as residential.

4.2.4 Sequoia Creek

The Sequoia Creek watershed is located in northern Corvallis. The creek runs about 3 miles southeast and then east from Chip Ross Park to its junction with Village Green Creek. The combined creeks run eastward through Stewart Slough and ultimately discharge into the Willamette River. The watershed's headwaters are steep and many are piped, and the stream is relatively narrow once its grade flattens out west of 9th Street.

Residential land use constitutes about half of the watershed's almost 1,400 acres, but significant commercial and industrial properties are concentrated in the stream's lower reaches. The lower reaches are also where some of the best habitat is located.

4.2.5 Garfield Basin

The Garfield watershed lies between the Dixon Creek watershed to the south and the Sequoia Creek watershed to the north. The small watershed, less than 350 acres, does not have year-round stream flow. Above Highway 99, storm flows are piped through an almost completely developed area, much of it commercial. Below Highway 99, only limited development has occurred. The flat topography and high groundwater table are the reasons for the large amount of wooded wetlands found in this downstream area.

4.2.6 Oak Creek

The Oak Creek watershed contains 8,300 acres, the largest watershed within the study area of the SWMP. The stream's headwaters are located northwest of Corvallis in McDonald State Forest. The creek follows Oak Creek Drive to the intersection of 53rd Street and Harrison Boulevard. Downstream of Harrison Boulevard, the creek flows through pastures and by farm buildings and research facilities owned by Oregon State University until it reaches the main campus. Oak Creek then flows through a short residential section south of the campus before flowing under Highway 20/34 and entering Marys River.

The largest current land uses include forest (about 6,000 acres) and agricultural (about 1,000 acres). Together they constitute over 80 percent of the watershed, and represent an opportunity to preserve or enhance currently undeveloped land. However, to accomplish watershed management, close coordination is required between Oregon State University, which manages both the forest and agricultural land, and Benton County.

4.2.7 Marys River

The Marys River watershed extends well beyond the borders of the study area. Only three small drainages containing a total of 78 acres within the Corvallis Urban Growth Boundary (UGB) were included in this study. These drainages lie south of the Corvallis Country Club and flow southward down the hill and into the Marys River floodplain. Open space and low-density residential are the current land uses, but the area is undergoing significant development. In the future, low-density residential will cover 69 acres, and the rest preserved with an open-space conservation designation.

4.2.8 South Corvallis

The South Corvallis watershed lies on either side of Highway 99, south of the Marys River. Areas west of Highway 99 drain to the Marys River, while areas east of Highway 99 drain to the Booneville Slough and the Willamette River. The South Corvallis Drainage Master Plan (SCDMP) was completed in 1996 to address flooding problems, mainly in areas south of Goodnight Avenue (City of Corvallis, December 1998).

The current study addressed two drainage basins not included in the SCDMP: Millrace and Goodnight Avenue. Both basins are flat and prone to flooding. Existing land use in the 350-acre Millrace drainage basin is a mixture of residential, industrial, and undeveloped property. Existing land use in the 300-acre Goodnight drainage basin consists mainly of residential and undeveloped properties. Undeveloped properties in the Millrace drainage basin are expected to become commercial in the future. Undeveloped properties in the Goodnight Avenue drainage basin are designated as residential. A small, fully developed drainage area called Ryan Creek has seasonal flows that discharge into the Willamette Park area.

4.3 AREAS OUTSIDE THE CITY LIMITS

Figure 4-1 shows the boundary of the study area. The boundary is determined from topographic considerations completely independent from jurisdictional boundaries. As a result, the boundaries of most watersheds within the study area extend beyond the Corvallis city limits. The areas outside of the city limits and inside the UGB are scheduled for ultimate buildout but are not yet part of the City. As growth continues, these areas may ultimately be annexed into the City. Benton County has jurisdiction over areas outside the city limits as well as areas outside the UGB. Implementing watershed-wide stormwater management practices will require the cooperation of the City and Benton County.