SECTION 4

Basin Delineation and Model Parameters

The McMinnville watershed was delineated into sub-basins as part of the 1991 master planning effort for the purpose of modeling drainage flows within the storm drainage system. This section describes the process used to delineate the major drainage basins and sub-basins within those major basins. It also explains the conventions used for referencing the sub-basins and briefly describes each major drainage basin within the McMinnville watershed including a summary of acreages. The following sections describe and then quantify the other input parameters for the computer runoff model: effective impervious area (EIA), soil loss parameter, and lag time.

4.1 Major Drainage Basins

The major drainage basins are shown in Figure 4-1. Major drainage basins were defined according to existing major drainage routings within the City. Most were natural waterways and their associated watersheds. These natural basins include Cozine Creek, West Cozine Creek, North Cozine Creek, and the "Highway" Basin, which is a natural creek system draining northeastern McMinnville and discharging into the North Yamhill River. Several major drainage basins were defined as such because they were areas that discharged directly into the major waterways passing through McMinnville: South Fork of the Yamhill River, North Fork of the Yamhill River, Baker Creek, and the East Basin, which includes the Municipal Airport. None of these four major basins has a single point of discharge, but rather each discharges into the associated waterway at a number of places.

Two areas primarily served by piped drainage systems were defined as major drainage basins: the Midtown Basin, which lies just northeast of City Center and drains through the sewage treatment plant, and the Combined Sewer area, which lies just east of City Center near East 3rd Street.

Areas of the UGB that were not part of the study area in the 1991 plan were incorporated in two ways. Portions of Cozine Creek, West Cozine Creek, and North Cozine Creek basins were part of the 1991 plan as offsite contributing sub-basins, and have been retained in the current update. New portions of the UGB on the eastern fringe of the City were assumed to drain directly to the Yamhill River, therefore not part of the previously delineated major basins or affecting them. For that reason, those areas have been otherwise removed from the analysis.

The names, abbreviations, and areas of the major basins are summarized in Table 4-1.

TABLE 4-1
Major Basin Areas
City of McMinnville Storm Drainage Master Plan

Major Basin Name	Basin Prefix	Drainage Area (acres)	Drainage Area Outside Proposed Urban Growth Boundary	Currently Developed Area within Proposed UGB – 2005 (acres)	Undeveloped Area within Proposed UGB—2005 (acres)
Cozine Creek	C	3,862	2199	741	922
West Cozine Creek	W	719	0	679	41
North Cozine Creek	N	1,125	20	871	233
North Yamhill	NY	528	0	189	360
Highway	H	638	1	536	101
Midtown	M	288	0	285	3
South Yamhill	SY	852	17	473	362
East End	E	1,549	102	795	652
Baker Creek	B	534	4	195	336
Yamhill Expansion Areas	Y	632	0	37	595
Total		**10,727**	**2,331**	**4,801**	**3,605**

4.2 Sub-basin Delineation Methodology

To refine the modeling analysis and facilitate identification of potential drainage problems and improvements, each major basin was further delineated into sub-basins. The factors used to delineate the sub-basins in the original 1991 Plan were as follows:

- **Size roughly between 60 and 120 acres**—Sub-basin areas within this range increase the modeling accuracy of peak flow analysis and are typically used in drainage master planning. Some sub-basins are smaller than 30 acres, particularly in the Midtown Basin and in the downtown section of the North Cozine Basin, due to presence of extensive piped networks. Sub-basins larger than 150 acres are located outside of the McMinnville UGB in the upper Cozine Creek Basin.
- **Similar zoning or land uses within sub-basin**—Since runoff rates and amounts are significantly impacted by impervious surface areas and since the amount of impervious surfaces is largely a function of zoning intensity, delineating sub-basins with relatively uniform land uses allows more meaningful runoff parameters to be estimated.
- **Consistent topography**—Since the time for runoff to reach the outfall of a sub-basin from the furthest reaches of the sub-basin is an important factor in the determination of peak flows and since flow time is related directly to slope, accuracy is improved if the sub-basin is drawn to include areas of relatively uniform slope.

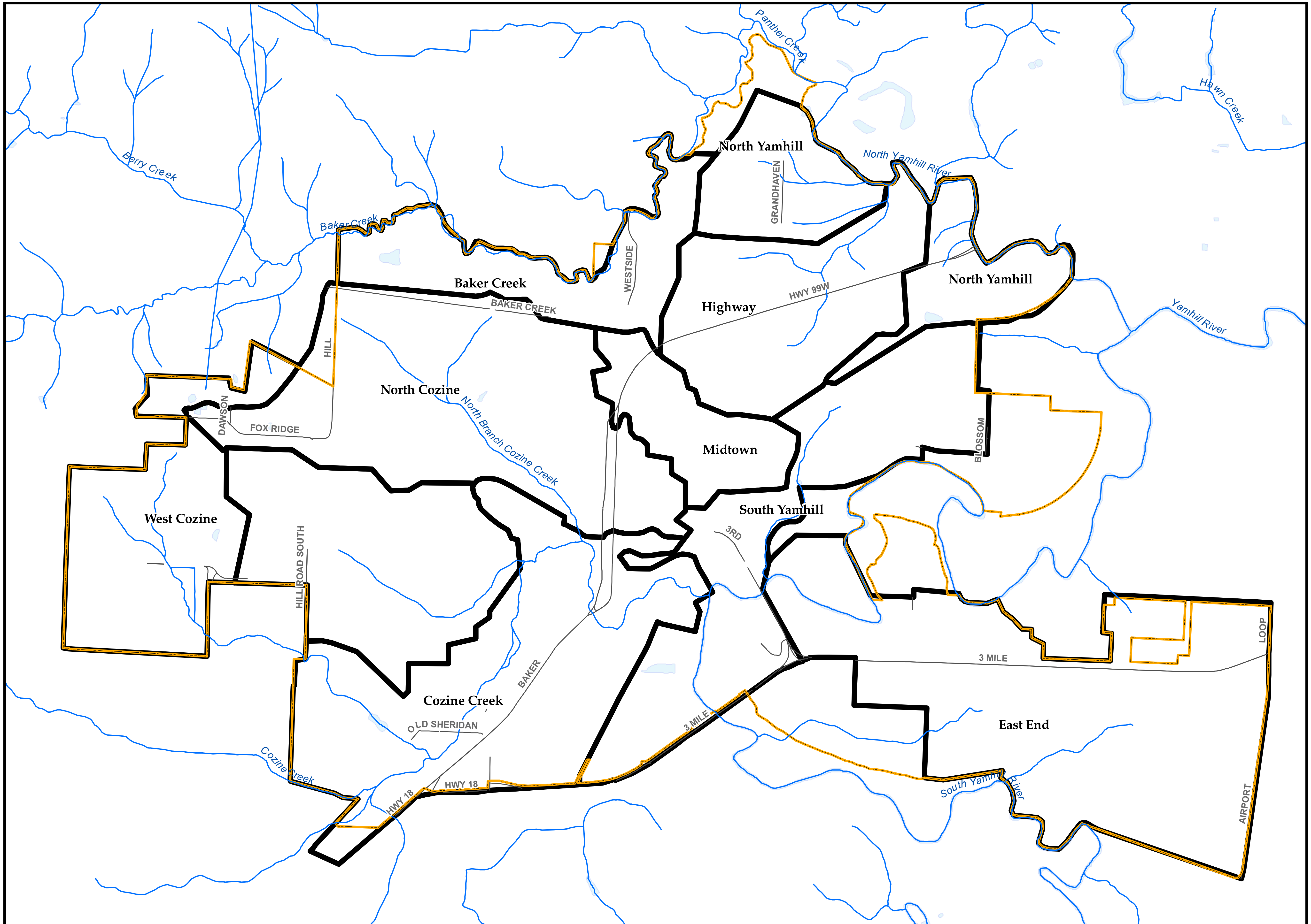

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FIGURE 4-1

MAJOR BASIN MAP

City of McMinnville
Stormwater Drainage Master Plan

Legend

- Creek\River
- Major Roads
- Proposed UGB
- Major Basin

N

1 inch = 2,500 feet

CH2MHILL

Date: 4/10/2009

- **Consistent soil type**—Since runoff is that portion of precipitation that is not absorbed by the soil or otherwise retained and since the type of soil is directly related to how much water infiltrates through the soil, the estimation of sub-basin flows is more realistic if the sub-basins are drawn to include areas of relatively uniform soils.
- **Common Outfall**—Generally, the sub-basin should be drawn so that all flow from the sub-basin discharges at one point, i.e., one storm drain outfall or a creek. For those sub-basins which lie along major waterways, discharges into the waterway are often numerous and sometimes indistinct. However, these sub-basins, which discharge along drainageways, can generally be considered as if they discharged at a single outfall into the waterway.

Using the above factors, this delineation process resulted in 144 sub-basins with areas generally ranging in size from 30 to 150 acres within the study area. The locations of these sub-basins are shown in Section 6, Runoff Analysis. The coding and drainage parameters of these sub-basins are described below.

In the current update, three sub-basin types were considered. Developed sub-basins were not changed. Sub-basins where development occurred between 1991 and 2007 were assumed to be within the same major basin with local drainage properly sized. Areas with expected future growth do not generally have detail to support subdivision. Based on the nature and location of expected development in the City, many expected growth areas will drain directly to a major drainageway, as do many of the 1991-2007 developments.

4.3 Sub-basin Coding Convention

Sub-basin coding is required as input into the stormwater computer models and is useful to reference drainage sub-basin areas. Each of the nine major drainage basins was assigned a prefix to facilitate sub-basin coding. The major drainage basins and their sub-basin code prefixes are listed in Table 4-1.

To describe the sub-basin coding convention used in this drainage master plan, a portion of the Cozine Creek drainage basin is used as an example. The sub-basins within the Cozine Basin are coded with the prefix "C." Each sub-basin has only one node where the runoff collected within the sub-basin is discharged either into the Cozine Creek or the next downstream sub-basin. The downstream node number and the sub-basin designation are the same. The node at the most downstream point within the Cozine Basin is numbered "0." Moving upstream along the basin's main waterway (Cozine Creek), each node is numbered sequentially in increments of ten. For example, sub-basins C-0, C-10, C-20, and C-30 lie along Cozine Creek. Sub-basins that do not lie directly along Cozine Creek but are contributing sub-basins are denoted with an "R" or an "L" appended to the receiving sub-basin number, depending on whether the outlet into Cozine lies to the right or left (facing upstream). For example, Sub-basin C-60L empties into C-60 from the left (facing upstream). A sub-basin that discharged into C-60L would be called C-60L1, so as to alternate between numbers and letters in the coding. A maximum of six digits is accepted by the HEC-HMS computer model.

An exception to this coding procedure is when a sub-basin discharges directly into a major waterway. In this case, the sub-basin is treated as a separate system and given an alphabetic, instead of a numeric, suffix. There are no examples of this in the Cozine Basin, but the entire Baker Basin, as well as portions of some of the North Yamhill, South Yamhill, and East Basins, are coded with alphabetic suffixes.

This coding convention gives some physical meaning to the sub-basin naming, which allows the flows within the system to be easily traced from one node to the next, facilitating analysis of the drainage system.

4.4 Description of Major Drainage Basins

The major drainage basins are shown on Figure 4-1 and described below.

4.4.1 Cozine Creek Basin (C)

The main stem of Cozine Creek drains the southwestern portions of McMinnville and a large area of predominantly agricultural land lying further to the southwest outside the UGB. The total area of the basin is approximately 3,862 acres. The area of the basin within the UGB is 1,163 acres. Land uses in areas within Cozine Creek and within the UGB are primarily residential, with commercial and light industrial uses south of the City Center. Cozine Creek is a deep, well-defined, heavily vegetated drainageway along most of its passage through the City. Cozine Creek empties into the South Yamhill River and is influenced by backwater conditions from the South Yamhill in its lower reaches.

4.4.2 West Cozine Basin (W)

West Cozine Creek is a major tributary of Cozine Creek. The West Cozine Basin is situated west of Highway 99 and lies completely within the UGB. It is approximately 720 acres in size and drains approximately 10 percent of the study area. Its westerly limits extend beyond Hill Road in the hillside areas at the west end of the City. This basin has experienced considerable residential development in recent years, converting rural farm lands to an urban landscape.

4.4.3 North Cozine Basin (N)

North Cozine Creek, which drains approximately 10 percent of the study area, is another major tributary of Cozine Creek. It is approximately 1,125 acres in area and generally situated north of Wallace Road and south of Baker Creek Road. The North Cozine Basin also includes a large older residential area, the Michelbook Golf Course, and most of the central business district.

4.4.4 Baker Creek Basin (B)

Baker Creek forms the northwest portion of the McMinnville UGB. Sub-basins in this major basin drain directly into Baker Creek, which flows in a well-defined channel.

4.4.5 Midtown Basin (M)

The Midtown Basin drains an area of the downtown central business district adjacent to the North Cozine Basin. It is approximately 288 acres in area and drains 3 percent of the study area. Runoff is collected in stormwater sewers and piped towards the Public Works

Complex at node M-O. This runoff receives treatment, combines with the treated effluent, and discharges into the South Yamhill River.

4.4.6 Highway Basin (H)

The Highway Basin drains an area of 640 acres and is situated east of the Midtown Basin. This basin drains runoff from Highway 99 West and the residential, commercial, and industrial areas north and south of the highway. Yamhill County Fairgrounds and Wortman Park are located within this basin. It is mostly piped at its upper reaches and remains an open ditch along its downstream reaches as it approaches the North Yamhill River.

4.4.7 North Yamhill Basin (NY)

The North Yamhill Basin is generally situated in the northeast corner of the study area on both sides of the Highway Basin. It is approximately 528 acres in area. The North Yamhill Basin drains to the North Yamhill River, which, in turn, joins the South Yamhill River approximately ½ mile outside of the UGB to the east.

4.4.8 South Yamhill Basin (SY)

The South Yamhill Basin is generally situated along the northeast boundary of the City to the east of the Southern Pacific Railway. It is approximately 852 acres in area. Runoff drains directly into the South Yamhill River. The South Yamhill Basin includes the large areas of industrially zoned lands along Riverside Drive and areas southeast of the railroad in the vicinity of Booth Bend Road.

4.4.9 East End Basin (E)

The East End Basin drains directly into the South Yamhill River. The East End Basin is the peninsula at the southeastern end of the City that is bordered to the north, west, and south by the meandering South Yamhill River. It is approximately 11,440 acres in area. Land in this basin is industrially zoned, but its current use is primarily agriculture except for the land occupied by the McMinnville Municipal Airport at the eastern end of the basin.

4.5 Effective Impervious Area

The amount of runoff is increased substantially by increased impervious areas within the sub-basins. Impervious areas, such as streets, parking lots, rooftops, sidewalks, and loading areas, increase the volume by preventing infiltration. Further, these impervious areas tend to concentrate the runoff into storm drains or ditches, which more rapidly convey the runoff to the receiving stream. This decreased time of conveyance decreases the time of concentration and generally increases peak rates of runoff downstream. Transformation of agricultural lands to highly urbanized lands can increase the rates and volumes of storm runoff by a factor of 2 to 4 times. Impervious area is a very significant factor in the analysis of storm drainage systems.

To estimate existing and future impervious conditions, aerial photographs (taken 2005) and the current City zoning map were used in the following manner.

Based on the aerial photographs, the areas of land currently developed were delineated. The area designated as currently developed was intersected with the City zoning map, by tax lot, to determine which parcels have been developed as of 2005. Developed tax lots were assumed to be developed to their maximum density. For developed parcels, an impervious area percentage was assigned by using typical values for a given zoning designation. See Table 4-2, Mapped Impervious Area Factors. The developed areas were then multiplied by these assumed factors to estimate the current mapped impervious areas (MIAs) within each sub-basin. The future condition scenario assumes full build-out to the UGB at maximum density. Therefore, all parcels within the UGB are given an MIA percentage based on the values in Table 4-2.

TABLE 4-2
Estimated Mapped Impervious Area by Zoning Designation
City of McMinnville Storm Drainage Master Plan

Zoning Designation	Estimated MIA
Residential	
R1 (9000SF/DU)	40%
R2 (7000 SF/DU)	50%
R3 (8000 SF/2 DU)	55%
R3 (1500 SF/DU)	65%
Commercial	
OR	90%
C1	90%
C2	90%
C3	90%
Industrial	
LM	80%
M1	80%
M2	80%

MIAs were converted to directly connected EIAs using the following regression equation, described in the 1991 plan:

$$EIA = 0.1 \times (MIA)^{1.5}$$

The value difference between mapped and effective impervious area accounts for those impervious areas that still contribute to rainfall losses, such as depression storage, and those areas that flow overland from impervious areas across permeable surfaces before reaching a defined drainageway. The above regression equation represents a rough estimate of EIA for planning level analysis. The actual EIA should be measured and verified as part of any future development project.

The results of the impervious area analysis for both present and future conditions are summarized in Appendix B. Effective impervious area was used as a calibration variable for the hydrologic runoff models.

4.6 Soil Loss Parameter

Soils in the area were characterized using the hydrologic soil classification system developed by the NRCS. Soils mapping and parameters were derived from the Soil Survey Geographic (SSURGO) Database, which was published by NRCS in 2003. For drainage purposes, each soil type in the SSURGO is given a hydrologic group designation (A, B, C, or D) which represents relative infiltration and runoff characteristics.

A hydrologic soil classification of *A* is typical of highly pervious soils with low potential for runoff, such as sands. A hydrologic soil classification of *D* would be typical of fine-grained impervious soils with high runoff potential such as clays. A listing of soil types found in the study area with their hydrologic soil classification is presented in Table 2-1.

This alphabetic classification can be transformed into a numeric value using “runoff curve numbers.” The NRCS runoff curve number procedure provides information that relates hydrologic soil group to runoff potential as a function of soil cover and antecedent soil moisture conditions. The curve numbers assigned to each of the hydrologic soil groups throughout the McMinnville area are listed in Table 4-3. These curve numbers were based on the NRCS TR-55 Technical Release Manual, Urban Hydrology for Small Watersheds, and adjusted for knowledge of local conditions.

TABLE 4-3
Curve Numbers by Hydrologic Soil Group
City of McMinnville Storm Drainage Master Plan

Hydrologic Soil Group	Curve Number
A	60
B	76
C	82
D	86

These numeric values were applied to the areas of mapped soil types within each sub-basin and a composite weighted average (by area) for soil type within each sub-basin was developed.

Soil loss parameter results are presented in Appendix B.

4.7 Initial Abstraction and Soil Retention

The initial abstraction (Ia) refers to rainfall that is intercepted, infiltrated, or stored on the surface (depression storage), before surface runoff occurs. This component of rainfall is often estimated as a function of the maximum soil retention (S), which is the limiting value of infiltration rate at the surface, transmission through the soil profile, or water-storage capacity. The following empirical relationship is used to relate maximum soil retention to the curve number for any given soil type:

$$S = [1{,}000/\text{Curve Number}] - 10$$

Empirical studies conducted by NRCS have shown that the initial abstraction can be approximated as a linear function of the maximum soil retention. NRCS reports suggest using the following relationship:

$$I_a = 0.2 \times S$$

4.8 Lag Time

Lag time is the delay in time, after a period of rain, before runoff reaches its maximum rate. This is a critical parameter that affects the shape and magnitude of the runoff hydrograph. However, it is also one of the most difficult to accurately quantify. One of the most common methods is to estimate lag time as a function of time of concentration. The following empirical relationship was used for this study:

$$\text{LAG TIME} = 0.6 \times T_c$$

The time of concentration is the time it takes for runoff to travel from the hydraulically most distant part of the basin to the point of interest, typically the basin outlet. The time of concentration is most commonly estimated by calculating and summing the travel times for a theoretical drop of water as it flows through various elements of the system.

Travel times were estimated according to the specific type of flow for that sub-basin, specifically overland flow, shallow concentrated flow, gutter flow, channel flow, or pipe flow.

Lag time was used as a calibration variable for the hydrologic runoff models.

4.8.1 Sheet Flow

Sheet flow is shallow (less than 1 inch) and unchannelized. The velocity of sheet flow is estimated using Manning's equation. Table 4-4 shows the Manning's roughness coefficients for various surface types. These values are consistent with the Oregon Department of Transportation (ODOT) Hydraulics Manual.

TABLE 4-4
Manning's Roughness Coefficients for Sheet Flow Analysis over Various Surfaces
City of McMinnville Storm Drainage Master Plan

Description of Surface Type	Manning's Roughness Coefficient, *n**
Pavement and Roofs	0.014
City Business Area	0.014
Gravel	0.020
Apartment Dwellings	0.050
Industrial Area	0.050
Urban Residential	0.080
Meadow, Pasture, Range Land	0.150
Rural Residential	0.240
Light Turf	0.240
Heavy Turf (Parks)	0.400
Forest	0.400

*ODOT Hydraulics Manual, June 7, 2006.

The overland flow time of concentration equation used from NRCS TR-55 is as follows:

$$T_c = [0.007(n \times L)^{0.8}] \,/\, [P^{0.5} \times S^{0.4}]$$

where:

T_c = time of concentration (hours)
n = Manning's roughness coefficient (dimensionless)
L = length of flow (feet)
S = slope (dimensionless)
P = precipitation (inches/hour), which for this case = 2.5 inches/hour

4.8.2 Shallow Concentrated Flow

After a distance of 100 feet, sheet flow typically becomes shallow concentrated flow, which is deeper and generally flows faster than sheets flow. Older documents describe this distance as 300 feet, the value used for calculations in the 1991 plan. The velocity of sheet flow is a function of surface type and slope. NRCS TR-55 provides a figure that relates slope to average velocity for both paved and unpaved surfaces. Two log-functions were developed from these curves, one for paved surfaces, and the other for unpaved surfaces. These velocity functions are:

Average flow velocity over paved surfaces: $V_{paved} = [S/0.00245]^{\wedge}(1/1.991)$

Average flow velocity over unpaved surfaces: $V_{unpaved} = [S/0.00393]^{\wedge}(1/1.985)$

where:

S = slope (dimensionless)

4.8.3 Gutter, Pipe, and Channel Flow

Once the flow intersects a gutter, pipe, or channel, the average velocity increases dramatically and it takes little time from there to reach the outlet. A constant average velocity was used to estimate travel times for this segment of the flow path. In pipes and channels, the average velocity was assumed to be 3 feet per second. For gutters, it was assumed to be 1.5 feet per second. All sub-basin parameters are summarized in Appendix B.

The time of concentration equation used for gutter, pipe, and channel flow is as follows:

$$Tc = L/3600 \times V$$

where:

T_c = time of concentration (hours)
L = length of flow (feet)
V = velocity (ft/s): gutter V = 1.5 ft/s; pipe V = 3.0 ft/s; channel V = 3.0 ft/s