CITY OF CORVALLIS

STORMWATER MASTER PLAN

September 2002

CORVALLIS
ENHANCING COMMUNITY LIVABILITY

CORVALLIS STORMWATER MASTER PLAN

Adopted March 4, 2002 (Ord. #2002-06)

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[1] *The Stormwater Planning Committee (SWPC) was able to review and edit only Chapters 1 through 5 of the Stormwater Master Plan. The SWPC did not review the basin chapters or associated projects.*

ABBREVIATIONS

BMP	Best Management Practice
B&W	Barney and Worth
cfs	Cubic feet per second
COE	U.S. Army Corps of Engineers
CWA	Clean Water Act of 1977
DEQ	Oregon Department of Environmental Quality
DSL	Oregon Division of State Lands
EIA	Effective Impervious Area
ENR	Engineering News Record
EPA	U.S. Environmental Protection Agency
EQC	Oregon Environmental Quality Commission
ESA	Endangered Species Act of 1973
ESU	Evolutionarily Significant Unit
F	Fahrenheit
FEMA	Federal Emergency Management Agency
FIA	Federal Insurance Administration
FIRM	Flood Insurance Rate Map
FR	Federal Register
HCP	Habitat Conservation Plan
ITP	Incidental Take Permit
LCOG	Lane County Council of Governments
LID	Local Improvement District
MDOE	Maryland Department of the Environment
mg/L	Milligrams per liter
MIA	Mapped Impervious Area
mL	Milliliter
MRCI	Municipal, residential, commercial, and industrial
MS4	Municipal Separate Storm Sewer System
NAQWA	National Water Quality Assessment Program
NCSCC	North Carolina Sedimentation Control Commission
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OAR	Oregon Administrative Rule
PFC	Properly Functioning Conditions
ODOT	Oregon Department of Transportation
PUD	Planned Unit Development
RUNOFF	Hydrologic model
SCS	U.S. Soil Conservation Service
SDC	System Development Charge
SDWA	Safe Drinking Water Act
SWMP	Stormwater Master Plan
SWPC	Stormwater Planning Committee
TM	Technical Memorandum
TMDL	Total Maximum Daily Load
UGB	Urban Growth Boundary
UIC	Underground Injection Control
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WPCF	Water Pollution Control Facility
WRD	Oregon Water Resources Department
WWTP	Wastewater Treatment Plant
XP-SWMM	EPA Stormwater Management Model, Hydrologic/hydraulic modeling package

GLOSSARY OF TERMS

Alluvial Stream – A stream that deposited the bed and bank materials of the channel perimeter under the present hydrologic regime. Alluvial streams have erodible boundaries and are free to adjust dimensions, shape, pattern, and gradient in response to change in slope, sediment supply or discharge.

Base Flood – Flood that has a 1 percent chance of occurring in any given year. This 100-year flood has been adopted by the Federal Emergency Management Agency (FEMA) for floodplain management purposes, and refers to a flood event that inundates the entire 100-year floodplain. (See "Floodplain, 100-Year" and "Flood, 100-Year.")

Beneficial Uses – The beneficial uses assigned by basin in the Oregon Administrative Rules for water quality and for Corvallis streams are as follows: public and private domestic water supplies, industrial water supplies, irrigation, livestock watering, anadromous fish passage, salmonids fish rearing and spawning, resident fish and aquatic life, wildlife and hunting, fishing, boating, water contact recreation, aesthetic quality, and hydropower, unless changed through a use attainability analysis.

Best Management Practices – Strategies for improving runoff water quality that are accepted throughout the industry. They include structural and non-structural measures to control pollutants at the source before they enter a stream. Structural BMPs include:

- Retention basins
- Detention basins
- Constructed wetlands
- Infiltration practices
- Filters
- Bioretention
- Biofilters (swales and filter strips)

Non-structural BMPs include:

- Street sweeping
- Illicit connection identification and elimination
- Public education and outreach
- Land use modifications to minimize the amount of impervious surface area
- Waste collection
- Proper materials storage

Bioswale – A constructed shallow, wide vegetated ditch through which storm runoff travels and that uses natural methods of cleaning water, such as sediment trapping and microorganism activity to remove pollutants.

City Limits – Boundary line that identifies land within the City.

Compatible – The ability of different uses to exist in harmony with each other. "Making uses compatible with each other" implies site development standards that regulate the impact of one use on another.

Corvallis Streams – All streams located either in part or entirely within the City's Urban Growth Boundary.

Density Transfer – Permits residential density under a single development application to be shifted from one part of a site and added to another part of the same site. It can be used to protect a wetland or other significant natural resource that is on the site without losing overall density in the development. Density transfer does not permit a net increase in density for the entire site, however it can specify that more intense residential building types are permitted within the area of the site that is to receive the density transfer.

Detention Basin – A constructed pond designed to temporarily collect runoff from a development to maintain the runoff rate to a specified pre-development flow.

Development – Making a material change in the use or appearance of a structure or land, dividing land into two or more parcels, changing the land use designation, or creating or terminating a right of access. Where appropriate to the context, development refers to the act of developing or the result of development.

Drainageway – Natural or artificial watercourse, including adjacent riparian vegetation, that transmits natural stream or stormwater runoff from a higher elevation to a lower elevation.

Drainageway Dedication – The transfer of ownership, in fee-simple, of a given piece of property for the purpose of stormwater functions.

Endangered Species – Any species in danger of extinction throughout all or a significant portion of its range.

Endangered Species Act – Federal regulatory program to protect fish, wildlife, and plants from extinction. It provides a means whereby the ecosystems upon which threatened and endangered species depend, may be conserved to ensure the continued survival of the species.

Enhance – Augment into a more desirable condition.

Erosion – Movement or displacement of soil resulting from natural and human-induced processes including weathering, dissolution, abrasion, corrosion, and transportation.

Flood, 100-year – A flood with a one percent chance of occurring in any given year. This is the flood most commonly used for regulatory purposes and is called the base flood. This flood event inundates the entire 100-year floodplain. (See "Base Flood.")

Floodplain – Area adjacent to a stream or a river channel that is covered by water when the river or stream overflows its banks.

Floodplain, 100-year – Area adjacent to a stream or river channel that includes land with a range of flooding frequency, from areas that flood frequently to the highest ground that has a one percent chance of flooding in any given year. The 100-year floodplain is the area subject to base flood regulations, and consists of the floodway and floodway fringe. (See "Base Flood" and "Flood, 100-Year.")

Floodplain Functions – Hydrological and ecological functions including temporary storage of floodwater, deposition of sediments outside of the channel, groundwater recharge, filtering of pollutants, and reduction of floodwater velocity and erosive forces. Also included, but to a lesser extent in previously urbanized areas, are such functions as nutrient exchange, refuges, and feeding areas for fish.

Floodway – River channel or other watercourse and the adjacent land areas that accommodate the base flood event without cumulatively increasing the water surface elevation more than 0.2 feet.

Floodway Fringe – Area of the 100-year floodplain lying outside of the floodway.

Flow-through Design – Typically a structure that does not hinder or obstruct the movement of, or displace, surface floodwater.

Hyetograph – A graph of rainfall intensity versus time.

Impact – The consequences of a course of action; the effect of a goal, guideline, plan, or decision.

Infill – Developing vacant and partially vacant land within a built environment. To be considered infill, such land shall be less than 0.5 acres in size for residentially designated lands or less than 1.0 acre in size for lands designated otherwise.

Intermittent Streams – An intermittent stream has flowing water during certain times of the year, when groundwater provides water for stream flow. During dry periods, intermittent streams may not have flowing water. Runoff from rainfall is a supplemental source of water for stream flow.

Key Areas of Exchange – Locations within a watershed where groundwater recharge from surface water occurs (e. g., permeable depressions) or where streams are fed by groundwater (e.g., springs).

Large Wood – The National Marine Fisheries Service defines large wood as 60 centimeters (24 inches) in diameter and at least 15 meters (49 feet) long. In the analysis of Corvallis' local streams done for the Endangered Species Act Salmon Listing Response Plan, large wood was identified as 10 centimeters (4 inches) in diameter and 3 meters (10 feet) long.

Maintain – Support, keep, and continue in an existing state or condition without decline.

Natural Swale – Naturally occurring linear depression that carries surface water only after rainfall. It also transports subsurface water seasonally or throughout the year.

NPDES – National Pollution Discharge Elimination System, which is the permitting system established by the Environmental Protection Agency to administer the Federal Clean Water Act.

Perennial Stream – A stream that has flowing water year-round during a typical year. The water table is located above the streambed for most of the year. Groundwater is the primary source of water for stream flow; runoff from rainfall is a supplemental source of water for stream flow.

Permeability – Ability of the soil to absorb water.

Policy – Decision-making guideline for actions to be taken in achieving goals and the community's vision.

Pre-existing Condition – Phrase used in the Stormwater Master Plan (SWMP) as a reference to the land characteristics and habitat condition prior to manmade modifications.

Preserve – Save from change or loss and reserve for a special purpose; the most strict non-degradation standard.

Pretreatment – Treatment of urban runoff prior to discharging into a public water body.

Properly Functioning Condition (PFC) – The National Marine Fisheries Service defines PFC as the sustained presence of natural habitat-forming processes that are necessary for the long-term survival of a species through the full range of environmental conditions.

Protect – Save or shield from loss, destruction, or injury or to save for future intended use. After "preserve," the next most strict non-degradation standard.

Redevelopment – Restoration or replacement of existing buildings.

Restoration – Process of returning an area to a close approximation of a former condition, and re-establishing functions.

Riparian – Land adjacent to a water body that directly affects or is affected by the aquatic environment. This includes streams, rivers, and lakes and their side channels, floodplains, and wetlands, and portions of adjacent slopes that shade the channel or provide streamside habitat. The area of transition from an aquatic ecosystem to a terrestrial system. (Note: This definition should replace the definition found in Article 50 of the Comprehensive Plan.)

Shall – Expressing what is mandatory.

Should – Expressing what is desired, but not mandatory.

Significant – A feature specifically identified as worthy of special recognition or protection (e.g., a "significant" wetland), or a resource that has been formally adopted by the City.

Stormwater – Rainfall or snowmelt that drains into public streams or pipes.

Stormwater Functions – Includes sustaining aquatic habitats, cleansing, nutrient transfer, and other beneficial functions.

Stormwater Phase II Rules – Federal Clean Water Act regulations that deal with runoff water quality issues, including pollutants and construction sediments. (See Appendix H for a summary of the Rules.)

Stream Corridor – Corridor of land of variable width along each side of a stream channel that is primarily reserved for stormwater-related and other stream system functions and processes.

Stream Corridor Functions – The attributes (uses and processes) connected with a stream corridor. These include ecological functions such as filtering pollutants, shading the channel, managing floodwater, supplying food for fish (insects, leaves, etc.) and other aquatic life, providing space for channel movement, and providing large wood to the channel when trees die.

Stream System – The channel, subsurface flow, and adjacent corridor, including the floodplain.

Sustainable – Able to be maintained or continued indefinitely.

Undeveloped Land in the Floodplain – Either (1) land that does not contain a primary structure or (2) in cases where land does contain a primary structure, then land that can be divided and the resulting vacant parcels can be developed per the Land Development Code.

Unwanted Species – Species that are either non-native or that do not contribute to the properly functioning condition of an adjacent stream.

Upland Natural Resources – Natural features and areas outside of the stream corridor and the 100-year floodplain that influence stormwater function and management. They include uplands, wetlands, vegetation, swales, and groundwater zones.

Urban Fringe – Area within the Urban Growth Boundary and outside the city limits.

Urban Growth Boundary – A line that circumscribes the urban fringe and the city limits and that is intended by state and local regulations to contain the area available to urban development.

Urban Stream – Seasonally or perennially surface-flowing watercourse with a defined channel, including watercourses in either a native or altered form.

Watershed – Drainage area of a specific stream system. Small watersheds are components of larger watersheds.

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EXECUTIVE SUMMARY

The City of Corvallis (City) worked with a 13-member Stormwater Planning Committee (SWPC) to develop the *City of Corvallis Stormwater Master Plan* (SWMP). The committee members were appointed by the Mayor and met over a 5-year period to support preparation of the plan. The SWMP makes recommendations to improve water quality, address existing and future flooding problems, and protect or enhance natural systems, including riparian, stream, and floodplain functions. It is intended to guide upgrades and expansion of the stormwater conveyance system and to guide stormwater management within the City over the next 20 years.

The recommendations will affect the City's capital improvement and operating programs. Stormwater utility rates and system development charges will need to be updated to finance the recommendations of the SWMP. Other recommendations include new City policy and development standards that will affect the way future development manages stormwater and the associated natural resources.

The SWMP's study area is defined by the natural drainage basins or watersheds that constitute the area's drainage system. The study area crosses City boundaries and extends into, and in some locations, beyond, the current Urban Growth Boundary, which represents the potential future boundary of the City, as shown in Figure ES-1. Recommended improvements for areas outside the current city limits will not be implemented until those areas are incorporated into the City or until a cooperative agreement is reached with Benton County.

The City and the technical consultant team worked closely with citizens, the SWPC, Benton County, and relevant regulatory agencies to develop the SWMP. Implementation of the SWMP will require active involvement of property owners, all City departments, state and federal agencies, and local stakeholders.

PUBLIC INVOLVEMENT

Implementation of the SWMP requires community support to be successful. A comprehensive public involvement program was included in the planning process to ensure that the SWMP addressed community values and concerns. The public involvement program included the following elements:

> An **SWPC** to provide ongoing review, guidance, and liaison with the community. SWPC members were appointed by the Mayor to represent a broad range of community interests. They played an integral role in each aspect of the planning process.
>
> **Interviews with community leaders and key stakeholders** to establish a baseline of public opinion and identify public sentiment toward the management of stormwater in the City. Fifty stakeholders representing a wide spectrum of the community participated in the survey, including landowners, business owners, residents, neighborhood and community organizations, local government representatives, state government representatives, Oregon State University representatives, Planning Commissioners, and City Councilors.

Public telephone surveys to solicit input from local residents.

Public workshops to solicit community input into the planning process, including two general meetings to identify public values, one meeting to finalize evaluation criteria, and two follow-up meetings to present stormwater recommendations to the public.

Workshops/meetings held for each group of watersheds to solicit input from local residents regarding problems, concerns, and their visions for the future. The workshops and meetings also served as a way to share with local residents the preliminary results of the modeling and alternatives development tasks. The eight watersheds were divided into three groups to facilitate meeting preparation and execution.

OBJECTIVES

Objectives were identified to guide the stormwater planning process based on seven categories of issues identified by the SWPC and the City. The issues to be addressed by the SWMP include:

- Stormwater quality
- Stormwater quantity
- Uplands and wetlands natural resources
- Floodplain
- Stream system
- Public participation and information outreach
- Cross-jurisdictional stormwater management

In addition, City policies were developed to support the objectives identified for each of the issues.

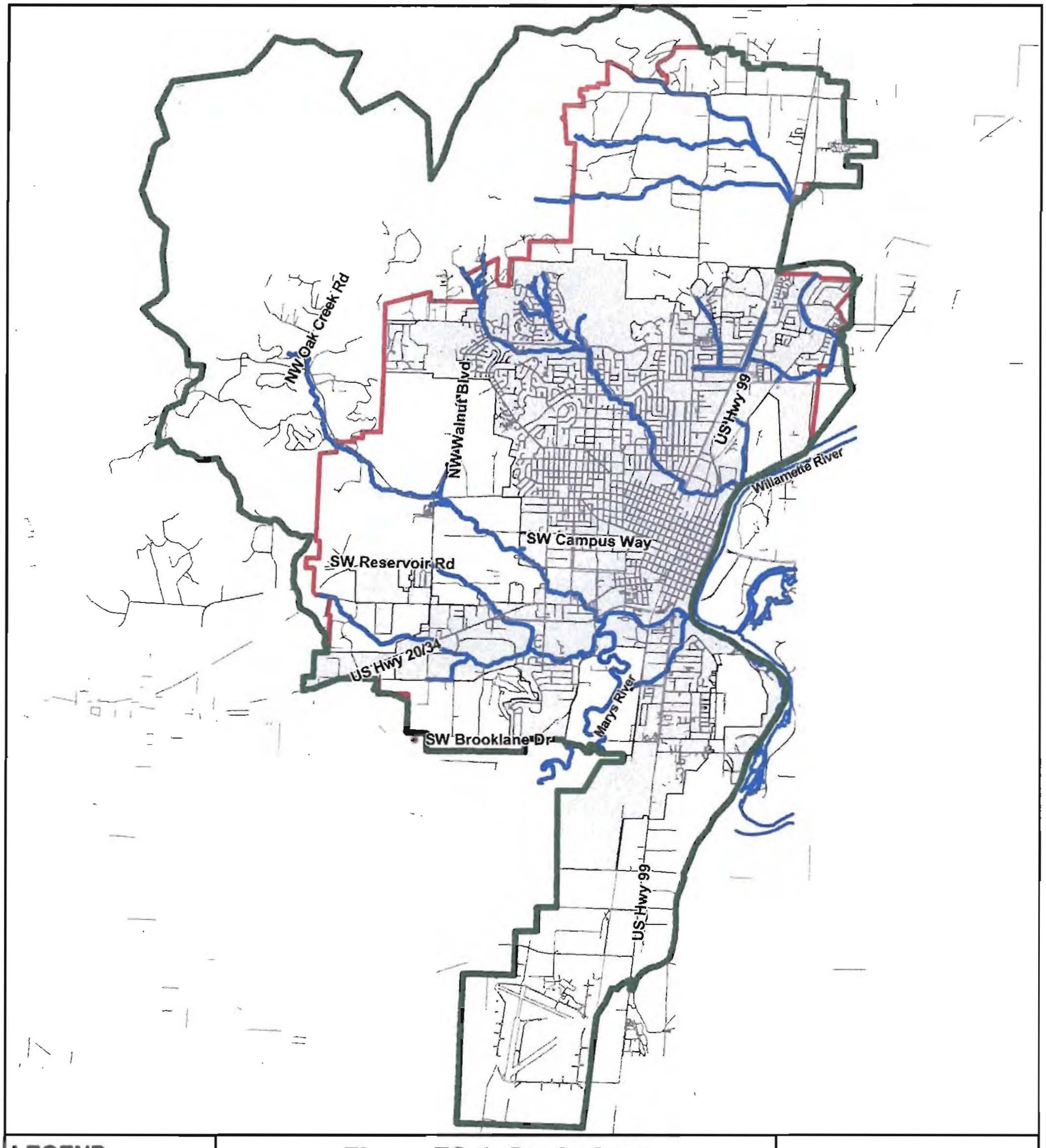
THE PLANNING PROCESS

The development of the SWMP involved a number of activities spanning multiple disciplines. The following activities were performed:

Description of planning area characteristics including topography, geology and soils, vegetation, climate, rainfall statistics, and land use. These factors play an important role in determining the quantity and quality of stormwater discharges.

Stream channel assessments of selected stream reaches to determine existing channel and bank conditions.

Figure ES-1 Study Area



LEGEND

Urban Growth Boundary

Study Area

City Limits

N

CORVALLIS Public Works Department

BROWN AND CALDWELL and Associated Firms

report/figu.../FigES-1.wor, December 8, 2000, base data from City of Corvallis GIS Department

Hydrologic/hydraulic modeling to analyze flows from existing and projected future (build-out) conditions. The hydrologic models determined the quantity of stormwater runoff to be conveyed by the manmade and natural conveyance systems. The hydraulic models determined whether the capacity of the existing conveyance system was adequate for the modeled conditions.

Regulatory review to identify state and federal regulations affecting stormwater and natural resource management.

Development standards review and recommendations to provide water quality treatment and detention of stormwater runoff for new development.

Alternatives development and analysis to address system deficiencies, based on the modeling results and on input from the public and City staff. Alternatives were generated based on the evaluation criteria developed by the SWPC.

Watershed recommendations to address the specific needs of each of the watersheds. Recommendations include specific projects, operation and maintenance requirements, and citywide measures that are addressed through the development of new City policy.

Implementation plan to prioritize implementation of recommended activities. The SWPC and City established two levels of prioritization: Short-Term and Long-Term Programs. The implementation plan identifies the cost of the capital improvements and maintenance recommendations.

The SWPC developed the following evaluation criteria to guide the development of the new SWMP:

- Maintains and accommodates natural hydrological processes.
- Protects and improves water quality.
- Protects and restores natural resources and ecosystem functions.
- Controls unwanted erosion.
- Meets current regulations and anticipated future regulations.
- Implements urban and rural land use objectives.
- Minimizes maintenance requirements and allows for maintenance access.
- Is designed and managed to avoid public health and safety hazards.
- Ensures that cost considerations are inclusive.
- Addresses cumulative impacts and off-site impacts.
- Explores and uses innovative and low-technology approaches.
- Incorporates community awareness.

The SWMP integrates the broader watershed and its functional elements and processes into stormwater planning and implementation. Streams that were viewed solely as water conveyance systems are seen as an integral part of the community's ecological health. Watershed planning is intended to provide a unified stormwater management strategy that will address water quality, water quantity, uplands natural resource and wetlands management, floodplain and stream-system management, and cross-jurisdictional basin management.

RECOMMENDED IMPROVEMENTS

The SWMP recommends a capital improvement program based on two levels. Projects are prioritized into either the short-term or long-term program. The short-term program is anticipated to be implemented over a 10-year period, followed by the long-term program. The implementation schedule for projects within each program is subject to a number of factors that requires annual evaluation of the priority ranking. City staff will ensure that the implementation schedule satisfies the needs of the community within the constraints of available funding.

Nearly $7 million in capital projects is recommended for the short-term program. The long-term program identifies approximately another $4 million in capital expenditures for a total stormwater capital program of approximately $11 million. Capital costs for both programs are listed in Table ES-1.

Table ES-1. Total Capital Cost of Recommendations

Activity	Short-Term Program ($)	Long-Term Program ($)	Total
Capital Fund			
Capital projects	$6,644,000	$4,416,000	$11,060,000

The short-term and long-term programs also define operation and maintenance costs. Table ES-2 lists the estimated costs for both programs.

Table ES-2. Total Operating Cost of Recommendations

Activity	Short-Term Program ($/year)	Long-Term Program ($/year)	Total
Operating Fund			
Operations and maintenance	180,100	164,000	344,100

FUNDING

The City has a stormwater utility for funding capital, operational, and maintenance activities. The monthly rates and system development charges will be re-evaluated as necessary to reflect the recommendations of the SWMP. Based on preliminary calculations, the monthly rate for funding the short-term program will be similar to charges levied by other major cities within western Oregon.

CITY POLICY

New policies were developed to address the issues identified by the SWPC and the City. Adoption of this SWMP includes the adoption of its new policy recommendations. The policies will augment existing City policy outlined in the Comprehensive Plan.

OTHER PLANNING DOCUMENT RECOMMENDATIONS

Several modifications to the Design Criteria Manual were recommended to address stormwater run-off quantity and quality issues. Additional planning document modifications will be required to support the new policies defined by the SWMP. The City will need to review the Municipal Code, Land Development Code, Design Criteria Manual, and Standard Construction Specifications to determine modifications required to support the SWMP. The City will also need to address new regulatory requirements, including the Endangered Species Act, National Pollutant Discharge Elimination System Phase II, Total Maximum Daily Loads, and the National Flood Insurance Program.

RECOMMENDATIONS

The City should initiate the following activities to support the SWMP:

- Conduct a rate study to update the City's stormwater rate structure
- Update other planning documents to support the SWMP and meet new regulations

CHAPTER 1

INTRODUCTION

1.0 VISION

The vision for the Stormwater Master Plan (SWMP) is an outgrowth of the Corvallis 2020 Vision Statement. Its purpose is to paint a picture for how stormwater will be addressed in the future.

We value our rivers, streams, and watersheds, carefully managing them to protect the purity of our water, their aesthetic and biological qualities, and their value as recreational areas. The City's streams and wetlands act as the backbone for a system of "green fingers" that weave through and connect the City's open space resources. These "green fingers" provide habitat corridors where native plants and wildlife flourish in their natural state. These "green fingers" widen out at community parks and open space preserves to provide additional storage capacity for flooding events.

Our natural open space helps buffer flood events, purify our air and water, provide recreational and educational opportunities, and reinforce the community's distinctive character. Corvallis has identified its open space resources, and has established criteria and priorities for open space protection. Natural flooding is encouraged, while urban flooding is managed through detention, enhanced stream capacity, and additional forest cover.

The community's water supply, streams, and creeks are clean and clear. Water conservation efforts decrease the amount of water City residents consume. Drinking water quality has been improved by convincing upstream entities to stop polluting the Willamette and its tributaries. Runoff from roads and other pollution sources is collected and treated before being discharged. We guard our precious water sources closely, by exercising extreme care in disposing of hazardous wastes, and we closely follow state and federal environmental regulations.

Pollution obeys no human boundaries. Recognizing that, the City coordinates its water quality efforts with other communities, surrounding counties, and resource management agencies in the Willamette Valley. This cooperative strategy has created a cleaner, healthier environment by encouraging improved farming and forestry techniques. Oregon State University and valley ranchers have helped improve stream water quality through better animal management practices and waste disposal methods.

The City provides leadership by managing each of its watersheds to accommodate natural hydrological processes. This is achieved through innovative low-technology approaches to watershed management. The City maintains stream functions within the urban areas while achieving compact urban form. Land use regulations for both urban and rural development ensure that stream functions are preserved and in some cases enhanced. Developers are informed of the implications associated with soil erosion during construction, and take special precautions to control unwanted erosion. The City has taken steps to protect and restore natural habitats, which have improved ecosystem functions. The City has developed implementation measures to ensure that long-term costs associated with new stormwater measures will benefit future generations.

Property owners adjacent to streams take an active role in maintaining and enhancing streamside property. This has been accomplished through an ongoing educational campaign that has heightened community awareness of natural stream functions.

1.1 INTRODUCTION

The City's SWMP recommends policies, activities, and programs formulated to improve water quality, address existing and future conflicts between flooding and development, and preserve and enhance valuable natural resources, including stream and floodplain systems. The recommendations will directly affect the City's capital improvement and operating programs. In addition, new policies and development standards have been recommended that will affect the way future development is conducted within the area. Implementation of the SWMP will require the active involvement and cooperation of all property owners, City departments, and State and federal agencies.

1.2 AUTHORIZATION AND PURPOSE

In December 1997, the City began developing an updated SWMP for guiding upgrades and expansion of the stormwater system to meet the area's needs over the next 20 years. The SWMP provides recommendations to address existing system deficiencies, projected growth-related requirements, and the requirements of State and federal regulations. The capital and operating costs for implementing project recommendations are identified.

1.3 BACKGROUND

The SWMP addresses the management of stormwater and natural stream systems within the study area illustrated in Figure 4-1. The study area extends beyond the City boundary and, in some places, outside of the current Urban Growth Boundary (UGB). The study area includes the entire drainage basin that contributes flow to each of the streams that pass through the City. This watershed-based approach to stormwater management provides a perspective for addressing all of the needs of each stream system and for including all of the stakeholders in the planning and implementation process. Stakeholders include the citizens living within the watershed, private and public property owners, the City, Benton County, and OSU.

1.3.1 Historical Drainage Management

The surface water drainage system has developed as one of the necessary components of infrastructure required to support City growth and vitality. Throughout the City's history, the drainage system has been constructed to convey surface runoff, to drain low areas as part of new development, and to prevent flooding. Water quality and natural resource protection objectives were not a part of early development activities. The area's streams were used, and continue to be used, as receiving points for local stormwater drainage.

Urbanization and past stormwater management practices have taken a toll on the City's streams, wetlands, and riparian areas. Increased development has increased the quantity of impervious areas, which directly affects stormwater runoff volumes and velocities. Increased stormwater runoff and higher velocities have upset the natural equilibrium of the stream, resulting in streambed and stream-bank erosion that is evident throughout the City. In addition, development tends to decrease the width of riparian and upland areas adjacent to streams. Loss of these natural areas reduces water quality, increases runoff rates, and decreases biological diversity. In general, urbanization negatively impacts the stream, riparian, wetland, and upland ecosystem. Chapter 4 provides a more in-depth discussion on the impacts of urbanization.

1.3.2 Previous Plans

Several planning documents have been previously developed to assist the City with its stormwater management:

- *Corvallis Drainage Master Plan*, CH2M Hill, May 1981
- *Dixon Creek Flood Reduction Analysis*, KCM, December 1997
- *South Corvallis Drainage Master Plan*, KCM, December 1998

The *Corvallis Drainage Master Plan*, completed in May 1981, formed the basis of the City's stormwater management for the next 20 years. Its focus was to develop infrastructure for the safe conveyance of stormwater flows. Water quality and natural resources were not addressed.

The *Dixon Creek Flood Reduction Analysis* addresses the specific needs of Dixon Creek. Frequent flooding along this stream, and in particular, the severe storm events of February and November 1996, threatened private property and the safety of local residents. In response, the City initiated the analysis to identify flood control measures for Dixon Creek. The analysis recommends 11 projects to address flooding, several of which have been implemented.

The *South Corvallis Drainage Master Plan* (SCDMP) was developed in 1996 and approved by the City in December 1998. The SCDMP addresses stormwater drainage issues in the southern portions of Corvallis that hinder development of vacant lands in the area. The SWMP augments the recommendations proposed by the SCDMP through measures that will affect stormwater management throughout the City.

1.3.3 Existing Stormwater Financing

In 1978, the City Council approved an ordinance establishing a stormwater utility. The utility was formed to fund capital improvements and activities as required for managing the City's stormwater conveyance system. In general, funds are generated by monthly fees to the utility users and by one-time System Development Charges (SDCs) for new construction. The funds generated by the monthly fees are used to address existing system deficiencies and to operate and maintain the conveyance system. Unlike the monthly fees, the SDCs are used to address extra-capacity or growth-related stormwater improvements.

In fiscal year 99-00, monthly fees generated approximately $1.5 million in revenue for funding stormwater related activities and improvements. Approximately 13,600 accounts (customers) contribute to the stormwater fund with rates based on equivalent surface units (ESUs). An ESU represents approximately 2,750 square feet of impervious surfaces. A monthly charge is levied against each ESU; in fiscal year 99-00 the charge was $4.23.

A citywide study in 1999 updated the SDCs. The charges will be updated again to include the funding recommendations of the SWMP. SDCs are an important component of the stormwater fund with approximately $44,000 added to the fund in fiscal year 99-00. In 2001, the storm drainage component of the SDC was calculated based on $0.0306 per square feet of impervious surface. For a 2,600 square foot single-family residence, this is equal to a one-time charge of $79.56.

1.4 SWMP OBJECTIVES

Early in the development of the SWMP, the City and the citizen-based Stormwater Planning Committee (SWPC) identified watershed-related management issues that needed to be addressed in the SWMP. Each issue constitutes an element of the overall watershed approach that forms the basis for the SWMP:

- Stormwater quality
- Stormwater quantity
- Uplands and wetlands natural resources
- Floodplain
- Stream system
- Public participation and information outreach
- Cross-jurisdictional stormwater management

The City and the SWPC identified objectives for each issue identified above. The overall management strategy focuses on achieving these objectives. Chapter 5 describes the objectives and the policies that were developed for addressing the issues.

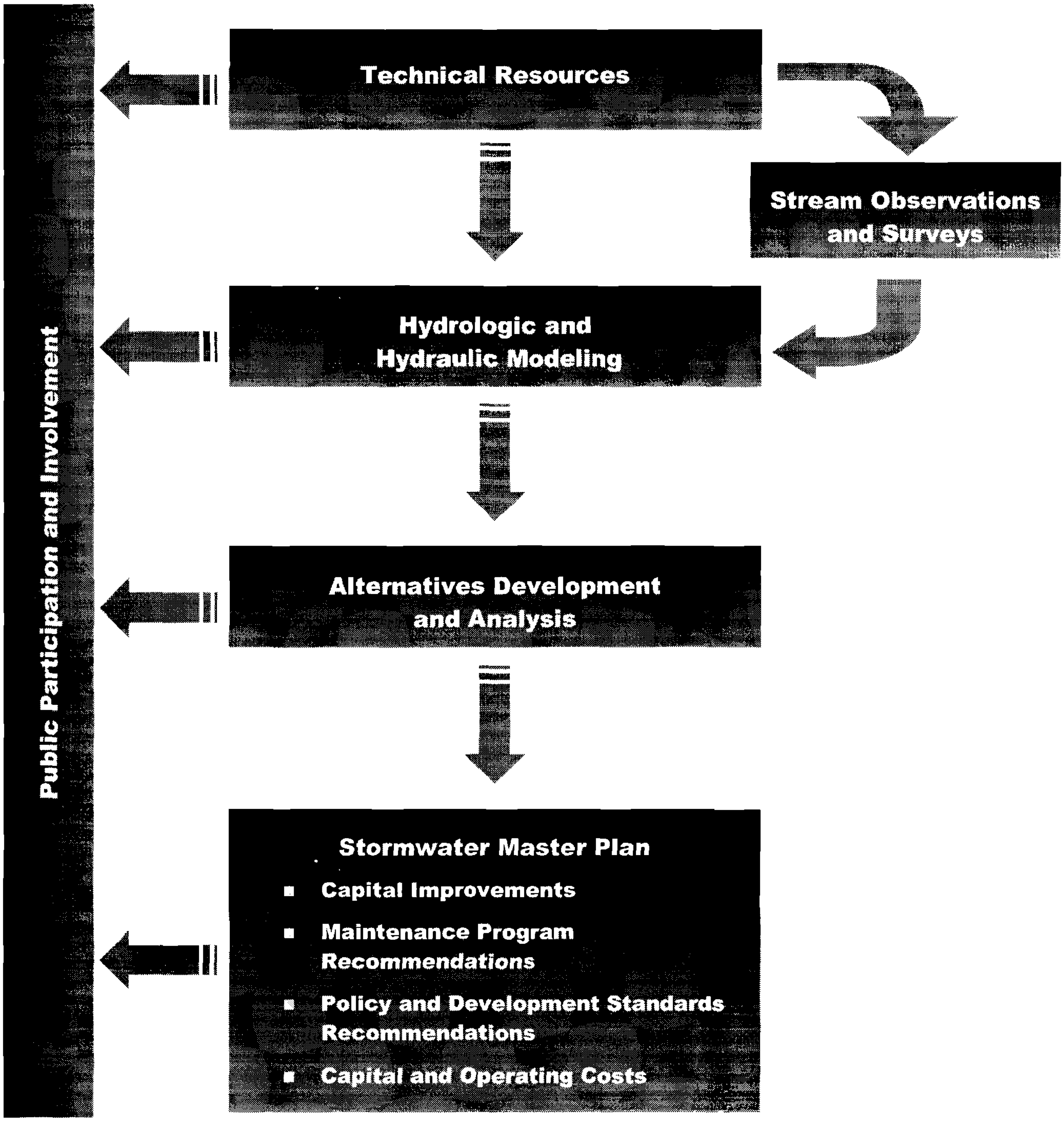
1.5 DEVELOPMENT PROCESS OF THE SWMP

The following tasks were required to be completed prior to the preparation of the SWMP.

- Public involvement process
- Field investigations
- Modeling and technical studies
- Identification of problem areas and opportunities
- Alternatives development
- Policy recommendation
- Capital improvement recommendation

Figure 1-1 shows the sequence of major tasks for developing the SWMP and the involvement of the public process.

Figure 1-1. Activity Flowchart



1.5.1 Public Involvement Process

The community's input and involvement during the planning process was of paramount importance to the City. The Mayor began the process by appointing the Stormwater Planning Committee (SWPC), as established by the City Council. The SWPC was to be involved with developing the community outreach program, participating in the selection of the consultant team, developing decision criteria for evaluation of options, overseeing technical work required for the plan, preparing draft and final plans, and making recommendations to the Council. The SWPC took a lead role in public outreach, including collecting citizen comments, identifying key public objectives and values to guide the planning, contributing to the selection and design of communications tools, facilitating public forums, and weighing the results of citizen feedback. In addition, the SWPC participated in the review and development of Chapters 1-5 of the SWMP and the development of policy recommendations.

Chapter 2 provides a detailed description of the public involvement process. The results of public meetings and surveys are summarized in Appendix A.

1.5.2 Collection and Development of Technical Resources

The recommendations provided by this SWMP are based in part on the physical characteristics of the City and surrounding study area. Information on rainfall quantity, intensity, and duration; soils; geology; topography; creek and storm conveyance system; land-use; and other physical factors were provided by the City or were obtained from other public-domain sources.

In addition, development of the SWMP involved conducting a field assessment of the existing channel and bank conditions at selected locations in each basin within the UGB. Locations were selected based on input from the SWPC and City staff, and a review of aerial photographs, maps, and information provided by the City (e.g., complaint and maintenance records). The first objective of the assessment was to characterize the general condition of the streams by noting items such as channel geometry, bank and bed stability, general floodplain functionality, vegetation and canopy, instream habitat, erosion and deposition, and accessibility for construction and maintenance.

Areas that presented opportunities for both immediate and long-term urban stream restoration, early action, and stewardship projects were also documented in the field notes from the stream observations. The City and SWPC were to consider applicable early action projects to be implemented while the SWMP was under development. Projects that might impact downstream conditions or that might have a large financial impact on the City were deferred for consideration and addressed during the development of the watershed plans found in Chapters 6 through 13.

Detailed results of the field investigations are available in Appendix B.

1.5.3 Modeling and Technical Studies

Models of the existing and future hydrologic conditions were constructed, tested, and run for each stormwater basin. The modeling addressed the main-stem open drainage and piped components of the stormwater system within the UGB. The existing land use was based in part upon review of digitized aerial photographs made available by City staff at the start of the project. Future scenarios were modeled using the full-buildout future land use condition, provided for in the City's Comprehensive Plan. Additionally, photogrammetric information from the City's geographical information system was used to estimate imperviousness for existing land uses. The models were used to identify problem areas and to provide an analysis tool during the alternatives analysis phase.

Technical Memorandum No. 1 in Appendix C summarizes the modeling process and lists the results of the modeling.

1.5.4 Alternatives Analysis

The alternatives analysis included analyzing the results of the public involvement, field investigation, and modeling tasks. It identified problem areas and proposed potential solutions. The City and the SWPC were involved during this stage to assist in crafting solutions that reflected the goals and values of the community.

1.5.5 The Plan

The City's existing stormwater planning documents are in need of significant review and updating to provide the necessary foundation for decisions related to the stormwater system and to future land use and development. The SWMP outlines the development of a new master plan for the planning, management, engineering, development, and regulation aspects of the City's stormwater utility for all areas within the Corvallis UGB. The new master plan incorporates environmental restoration and protection of the natural components of the stormwater utility.

The SWPC created the following evaluation criteria list that was used to guide the development of the new master plan.

- Maintains and accommodates natural hydrological processes.
- Protects and improves water quality.
- Protects and restores natural resources and ecosystem functions.
- Controls unwanted erosion.
- Meets current regulations and anticipated future regulations.
- Implements urban and rural land use objectives.
- Minimizes maintenance requirements and allows for maintenance access.
- Is designed and managed to avoid public health and safety hazards.
- Ensures that cost considerations are inclusive.
- Addresses cumulative impacts and off-site impacts.
- Explores and uses innovative and low technology approaches.
- Incorporates community awareness.

The SWMP integrates the broader watershed and its functional elements and processes into stormwater planning and implementation. Streams that were once viewed solely as water conveyance systems are seen as an integral part of the community's ecological health. Watershed planning is intended to provide a unified stormwater management strategy that will address water quality, water quantity, uplands natural resource and wetlands management, floodplain and stream-system management, and cross-jurisdictional basin management.

1.6 ORGANIZATION OF THE SWMP

The SWMP is organized as follows:

Executive Summary - Provides a brief summary of the SWMP in the form of a final project transmittal letter.

Chapter 1: Introduction - Describes the authorization and purpose, background, objectives, and processes for developing the SWMP.

Chapter 2: Public Involvement - Describes the major elements of the public involvement and outreach processes along with a summary of the results.

Chapter 3: Basis of Planning - Describes the basis for hydrologic and hydraulic modeling, the engineering standards to be used in developing alternatives, methods for estimating project costs, strategies used for developing improvement programs, and a summary of the regulations impacting the SWMP.

Chapter 4: Study Area Characteristics - Describes the physical characteristics of the study area, including geography, land use, geology, soils, climate, rainfall, and a description of the conveyance system.

Chapter 5: Community-Wide Stormwater Planning and Policies - Summarizes the existing planning framework and presents recommended policies for addressing the major issues that impact stormwater management within the City.

Chapters 6 - 13: Watershed Planning and Analysis - Describes the physical characteristics of the following watersheds, summarizes the major findings from the public process, documents City experience in the area, presents deficiencies in the conveyance system as identified by modeling, identifies problem areas, and recommends projects and activities to address deficiencies and to protect water quality, the creek, and natural resources in the area.

Chapter 6: Dixon Creek

Chapter 7: Squaw Creek

Chapter 8: Jackson/Frazier/Village Green Creeks

Chapter 9: Sequoia Creek

Chapter 10: Garfield Basin

Chapter 11: Oak Creek

Chapter 12: Marys River

Chapter 13: South Corvallis

Chapter 14: Implementation Plan - Summarizes the recommendations from all of the watershed chapters in terms of cost for the short- and long-term programs, identifies capital improvement and operating program costs, and discusses the next steps required for funding the SWMP.

Technical Appendices - Presents background and detailed information on the project, including stormwater-related regulations, public involvement process, summary of the streamwalk observations, a technical memorandum on the hydrologic/hydraulic modeling, technical memorandum describing the basis of costs, and other related information.

CHAPTER 2

PUBLIC INVOLVEMENT

Public involvement is an important component of a successful planning process. This chapter describes the public involvement process for the Stormwater Master Plan (SWMP). The objectives of the public involvement process are discussed, as are the use of public surveys, public meetings, and incorporation of public concerns into the evaluation criteria.

2.1 OBJECTIVES AND GOALS

The City of Corvallis' (City) goal was to begin public involvement in the first days of the project and continue through plan adoption and implementation. The City Council directed the Mayor to appoint the Stormwater Planning Committee (SWPC) to facilitate and guide the public process required for the SWMP. The SWPC was selected to represent a cross-section of stakeholders in Corvallis, including citizens-at-large, whose task was to provide input into the development of a master plan to address existing and potential future stormwater issues in Corvallis.

The City designated the SWPC to lead implementation of the public involvement plan. The SWPC listened to citizens, identified key public values to guide planning, contributed to the selection and design of communication tools, participated in public meetings, and weighed the results of citizen feedback. As part of this responsibility, the SWPC met approximately every other week throughout the length of the project.

2.2 RESULTS FROM THE SURVEYS

At the beginning of the project, a public involvement consultant conducted a telephone survey of Corvallis residents. The survey served to "provide guidance to the Stormwater Planning Committee around public opinion and identify public sentiment toward the management of stormwater in Corvallis." Its purpose was to solicit input from the broader community affected by stormwater planning who might not typically participate in a public process to voice opinions and concerns.

The telephone survey was conducted in late December 1997 and early January 1998. A total of 366 residents responded to the survey. The results are consolidated into four basic thoughts:

- While residents generally lacked knowledge of the specifics of their stormwater service, they recognized the importance of the public safety and environmental impacts of stormwater management.

- Development was not seen as necessarily negative, but was recognized as impacting stormwater issues.

- Due to its impacts, development should help finance improvements and enhancements to the City's stormwater system.

- Residents acknowledged that while system development charges should pay for upfront costs, they are willing to accept responsibility for ongoing maintenance costs.

Details of the telephone survey are in Appendix A.

In addition to the telephone survey, lengthier interviews were held with community leaders and key stakeholders. Fifty participants were asked to share their views related to stormwater issues, the nature and severity of flooding problems, causes and possible solutions to flooding, values and principles to guide decision making, costs, and means for citizen participation. Among the persons interviewed were representatives of Corvallis neighborhood associations, environmental/clean water advocates, developers and homebuilders, business community leaders and employers, regulatory/resource agency personnel, members of the City Council, and area residents and property owners in affected watersheds. The key points offered by the stakeholders are:

1. Flooding is not the main problem.
2. Solutions must be site-specific.
3. Multiple-benefit and "natural" solutions are preferred.
4. A basin-by-basin approach to stormwater planning is necessary.
5. Public agencies should set a good stewardship example.
6. Existing ratepayers and new development should equitably share costs of stormwater system improvements.
7. The best methods of public outreach target lay citizens.
8. Gaining broad-based citizen understanding of stormwater issues will require a long-term commitment to public education.
9. The stormwater master plan should provide solid guidance for managing stormwater while maintaining and enhancing livability.

Additional discussion of the stakeholder survey is in Chapter 5. The full results are included in Appendix A.

2.3 PUBLIC MEETING FEEDBACK

A number of public meetings were held during the course of the project to distribute information about watershed planning efforts and to solicit input. A public project kickoff meeting was held on May 28, 1998. A subsequent public meeting on July 7, 1998, centered on identifying public values and, on December 3, 1998, a third public meeting was held to finalize public values and develop evaluation criteria.

Following the general public meetings, additional public meetings were held for each group of watersheds in the UGB. Two meetings were held for each group at a location within one of the watersheds to solicit input from local residents and interested citizens about problems, concerns, and their visions for the future. Preliminary results were also shared with the public at these meetings. Table 2-1 lists the watershed meeting dates.

Table 2-1. Public Meetings for Watershed Groups

Watershed Group	First meeting	Second meeting
Dixon Creek	March 30, 1999	April 6, 1999
Squaw Creek	March 30, 1999	April 8, 1999
Jackson Creek, Frazier Creek, Village Green Creek, Sequoia Creek, & Garfield Drainage	June 15, 1999	July 20, 1999
Oak Creek, Marys River, & South Corvallis	June 19, 1999	September 30, 1999

Feedback from the public varied from general comments about the watershed planning process to specific comments about local problems. The comments were recorded at each meeting and incorporated into the appropriate chapters of the SWMP. Each watershed chapter (chapters 6 through 13) lists the general public remarks pertinent to that watershed, and lists site-specific remarks in the relevant stream reach section. Public remarks were minimally edited to preserve the context. All of the remarks recorded in the public meetings listed in Table 2-1 are in Appendix A.

Public comments were used in several ways during the course of this project. The comments served to alert the project team to problems and concerns that may not have shown up in City staff reports, field investigations, or modeling; they confirmed problems and concerns noted by the other sources; and they helped formulate the public's vision for the future, which influenced the choice of alternatives for each watershed.

2.4 EVALUATION CRITERIA

The SWPC identified the evaluation criteria to be used in the formulation of the SWMP based on important issues expressed by members of the public. Participants reviewed the draft criteria during public meetings before it was finalized. The final criteria for the master planning process are:

- Maintains and accommodates natural hydrological processes.
- Protects and improves water quality.
- Controls unwanted erosion.
- Protects and restores natural resources and ecosystem functions.
- Meets or exceeds current regulations and anticipated future regulations.

- Ensures that cost considerations are inclusive.
- Addresses maintenance requirements and allows for maintenance access.
- Incorporates community awareness and information exchange.
- Addresses cumulative impacts and off-site impacts.
- Is designed and managed to avoid public health and safety hazards.
- Incorporates community amenities.
- Explores and uses innovative and low-technology approaches.
- Implements urban and rural land use objectives.

The final criteria were presented to the public in the Stormwater Alternatives Workshop on March 16, 2000. At the workshop, the public worked in small groups to rank the importance of the evaluation criteria. The results were used to recommend changes to the City's Comprehensive Plan and to help formulate appropriate projects and activities for each of the watersheds. Further explanation of the criteria is in Appendix A.

2.5 PUBLIC MEETINGS TO REVIEW THE DRAFT PLAN

The SWPC, in conjunction with the City Council Urban Services Committee, hosted two public meetings on August 14 and August 16, 2001, to collect comments on a complete draft of the SWMP. Before final adoption, the Corvallis Planning Commission and the City Council conducted public hearings to consider public comments relevant to the Plan.

CHAPTER 3

BASIS OF PLANNING

The stormwater master planning process used available physical and scientific information, and included a number of assumptions. This chapter describes the information and assumptions that formed the basis of planning for the Corvallis Stormwater Master Plan (SWMP), including the time-frame for the project, level of service provided, engineering standards, modeling parameters, methods for estimating costs, implementation strategies, and related regulations. The basis of planning provides a reference point from which to evaluate the results and recommendations, and for updating the plan in the future.

3.1 TIME FRAME FOR ANALYSIS

In the fall of 1997, the City of Corvallis (City) contracted with Brown and Caldwell to assist in developing the SWMP. The most current information was used to construct the models and perform the analyses.

The City provided mapping (e.g., streets, tax lots, streams, water bodies, and other major features) from its Geographic Information System. Lane County Council of Governments (LCOG) provided information on land use based on 1999 information. LCOG was under contract with the City Planning Department to update land-use maps for the City's *Draft Corvallis Comprehensive Plan* (1998). Photogrammetric coverage with 2-foot contour increments from 1998 was used to define the topography of the study area. Information on the collection system (e.g., pipe diameters, invert elevations, depth of cover, and channel geometry) was provided by the City over the course of the project. City survey crews collected field data as necessary. The consultant team collected other data during stream walks or other field investigations.

3.2 LEVEL OF SERVICE

The City's *Design Criteria Manual for Public Improvements* (July 1991) specifies a "10-year design storm" for sizing storm drains. In general, this pertains to a collection system designed to convey storm flow that is expected to occur approximately once every 10 years. The 10-year design storm was used to size pipes, culverts, and bridges modeled by this planning effort. Other design storms were modeled, including the 2-, 5-, 25-, and 100-year storm events, to determine how the stormwater collection system would react under these different storm conditions.

The 25-year storm event was modeled to identify the required capital improvements should the City choose to use a 25-year design storm in the future, rather than the 10-year storm that is the design basis of the existing system. The costs associated with upsizing the stormwater conveyance system were determined to be excessive compared to maintaining the current 10-year design storm basis. The 100-year event was also modeled to assist in identifying properties that would be impacted by this large storm event.

The 2-year storm was used to evaluate the potential for stream erosion because this size storm is responsible for most sediment transport and channel-forming activity in streams. The channel-forming or dominant discharge is a theoretical discharge that, if maintained in an alluvial stream over a long period of time, would produce the same channel geometry that is produced by the long-term natural hydrograph. Channel-forming discharge is the most commonly used, single independent variable that is found to govern channel shape and form. Channel-forming discharges are found in storm events with 1- to 2.5-year recurrence intervals (USDA, 1998). Studies in King County, Washington, confirmed that the 1- to 2-year flows moved the most sediment over time (Booth, 1997).

The velocity at which channel erosion begins depends on a number of factors including the slope of the channel, steepness of the streambanks, soil characteristics, and the amount and type of stabilizing vegetation. A threshold of 4 feet per second was chosen for stream erosion based on allowable velocities for cohesive soils and/or grass-lined channels (NCSCC, 1988; MDOE, 1998; Smoot and Smith, 1999).

3.3 ENGINEERING STANDARDS

The following engineering standards were used to determine system deficiencies and needed improvements:

- Surcharged pipes were classified as undersized. However, they were not recommended for replacement unless surface flooding had also been observed.

- The installation of a parallel pipe to increase capacity was not considered to be cost-effective due to conflicts with other utilities. Replacement of the undersized pipe with a larger pipe was recommended as the more desirable solution.

- Culverts were considered to be appropriately sized if they could convey the 10-year design storm flows without creating upstream backwater conditions. Culvert replacement or the installation of a parallel culvert was recommended when headwater conditions created by an undersized culvert threatened upstream property or the stability of a roadbed. The recommendation of either a new replacement culvert or a parallel culvert was based on cost and on the physical geometry of the site.

- Existing bridges that passed flows from the 10-year design storm were considered adequately sized. Bridges for Oregon Department of Transportation (ODOT) roads are designed for larger storm events, but the SWMP identifies only the deficiencies associated with the 10-year design storm.

3.4 MODELING PARAMETERS AND ASSUMPTIONS

The product, XP-SWMM (Stormwater Management Model) version 5.2, was selected as the hydrologic and hydraulic model for the project. The model enables the user to perform a detailed examination of flooding, backwater, and velocities within the stream and piped system. XP-SWMM contains a modified version of the U.S. Environmental Protection Agency's SWMM program.

The model was used to predict peak flows, water elevations, and velocities for existing and future development conditions for 2-, 5-, 10-, 25-, and 100-year design storms. The model was used to identify flooding problems, size pipes and culverts, and identify stream reaches susceptible to excessive erosion.

The following subsections describe the design storms used in the modeling process. The subsections include a summary of model calibration efforts and a brief discussion of model assumptions.

3.4.1 Design Storms

The design storm used in the modeling was based on an actual Corvallis rainfall event. The rainfall distribution (incremental volume over time) of the design storm was based on the rainfall pattern from the December 24 to 29, 1998 storm event. During this 5-day period, 5.15 inches of rain fell with 3.64 inches accumulating in the 24-hour period beginning at 1 p.m. on December 27. This 24-hour rainfall volume is approximately equal to the 10-year event predicted by the National Oceanic and Atmospheric Administration (NOAA) Atlas X (1973) commonly used for deriving design storms. The days before and after this event were included in the model to allow the model time to come to equilibrium with the rainfall and soil moisture conditions.

To model other storm events, the rainfall distribution for the 10-year storm was modified by multiplying the incremental volumes by the factors listed in Table 3-1. The storms used in the model included the 2-, 5-, 10-, 25-, and 100-year storms.

Table 3-1. Design Storm Rainfall Multiplier

Return frequency (years)	2	5	10	25	100
Multiplier	0.7	0.8	1.0	1.1	1.3

This approach was used in lieu of a traditional synthetic design storm, such as the SCS Type IA distribution. The U.S. Soil Conservation Service developed this methodology in the mid-1980s (SCS, 1986). Although the SCS Type IA storm has been widely used throughout the Pacific Northwest, the use of a rainfall distribution based on historic rainfall records more closely reflects the type of storm distribution found in the Willamette Valley. In general, the typical Willamette Valley storm distribution does not have the short, steep sloped hyetograph (a graph showing rainfall over a period of time) associated with the SCS Type IA storm. To more closely approximate storm patterns found in Corvallis, the hyetograph for the design storm had more gradual leading and trailing edges. (See Appendix C for more details.)

Peak flows in stormwater systems are highly dependent on the soil conditions present before a storm (antecedent conditions). The peak flow rate generated from a given storm may have a recurrence interval different from that of the rainfall event due to varying soil moisture conditions. Design storms constructed from SCS distributions and 24-hour rainfall volumes tend to create higher peaks than those that are observed in long (25+ year) simulations using actual rainfall records, (Bedient and Huber, 1993). Thus, the true return period for a simulated storm event is uncertain.

Distributions and 24-hour rainfall volumes create higher peaks and lower total volumes than what has been observed in long (40+ year) simulations using actual rainfall records. The SCS distributions do not accurately account for antecedent rainfall by allowing too much of the rainfall to infiltrate at the beginning of the storm.

3.4.2 Model Calibration

The calibration data used for this study was based on water surface elevations measured during the December 24 to 29, 1998 storm and from anecdotal information. The public provided information on storm and flooding events during public meetings and by City engineering and maintenance personnel familiar with the storm collection system. In addition, previous master planning efforts had model results that were compared to the new XP-SWMM models.

Calibration data was available for Dixon and Squaw Creeks. Table 3-2 presents the results of the calibration effort based on surface water elevations from the December 24 to 29, 1998 storm. In general, the model predicted water surface elevations similar to actual observed conditions. The results were consistent with model tolerances based on available channel and calibration data.

Table 3-2. Calibration Results

Location	Measured elevation, feet	Modeled elevation, feet
Dixon Creek		
9th Street bridge	217.8	218.6
Grant Avenue bridge	224.2	225.4
Garfield Avenue bridge	228.3	228.3
Circle Boulevard bridge	240.0	240.2
Squaw Creek		
Knollbrook Place bridge	225.7	225.6
Country Club Place culverts	237.5	237.8

3.4.3 Model Assumptions and Limitations

This modeling effort was primarily aimed at determining system deficiencies related to flooding and flow restrictions resulting from improper channel or pipe size. Modeling of the pre- and post-development peak runoff flows was not meant to be used to quantify the effects of urbanization. Instead, modeling data were developed to determine flow relative to conveyance capacity for the purpose of sizing pipes, culverts, and other structures. To develop conservative recommendations for storm drainage infrastructure, a worst-case scenario was modeled. That scenario assumed that the peak rainfall occurred coincident with high soil saturation and that the storage and infiltration capacity was low for both the pre- and post-development conditions. Thus, most of the precipitation that fell was converted to surface runoff, and this assumption led to pre- and post-development peaks that were relatively close and high in magnitude.

Although this assumption provided a sound approach for determining system deficiencies, it would not be appropriate for a modeling effort aimed at quantifying the differences in pre- and post-development runoff. While the modeled effect of little change in pre- and post-development peaks may be true for rare storms with return periods greater than 5 to 50 years and with high rainfall volumes, it would not be realistic for smaller, more frequent storms under less saturated conditions where a greater proportion of the precipitation that falls would be stored and routed as subsurface flow. A greater difference in development-related runoff response would result compared to that shown in the model. The difference would be more pronounced in the hillslope areas with deeper, loamier soils and greater storage capacities compared to the areas with clayey soils on the valley floor.

The model showed only runoff as surface flow; no subsurface and interflow storage and runoff mechanisms were included. The shift in the dominance of subsurface storage and runoff components in pre-developed conditions to surface runoff dominance in post-development conditions for the greatest percentage of storm events was not represented.

In addition, the modeling was not intended to provide direct water quality information or flow analyses necessary for determining mass loading of water quality components. Additional assumptions regarding modeling are in Appendix C.

3.5 METHODS FOR ESTIMATING COSTS

Project costs vary depending on the specific conditions of the project site. The accuracy of the cost estimate, therefore, depends on the amount of site information available, as discussed below. This information is expanded upon in Appendix D.

Type of Estimate – The costs developed for the SWMP are order-of-magnitude estimates, and not budget estimates or definitive estimates, as defined below.

- **Order-of-Magnitude Estimate** – This type of estimate is approximate, and is made without detailed engineering data. Calculations involving cost-capacity curves, scale-up or scale-down factors, and ratios are used in developing such an estimate. Typically an order-of-magnitude estimate is considered accurate within a range of plus 50 percent or minus 30 percent. That is, the final cost may be as much as 50 percent more or 30 percent less than the estimated amount.

- **Budget Estimate** – This estimate is prepared based on field observations, or using process flow sheets, layouts, and equipment details. A budget estimate is normally accurate within plus 30 percent or minus15 percent.

- **Definitive Estimate** – As the name implies, this is an estimate prepared from well-defined engineering data, such as construction plans and specifications. At a minimum, the data must include fairly comprehensive plot plans and elevations, piping and instrument diagrams, one-line electrical diagrams, equipment data sheets and quotations, structural drawings, soil data and drawings, and a complete set of specifications. The most accurate estimate would be based on construction drawings and specifications. The accuracy of a definitive estimate would fall within plus 15 percent or minus 5 percent.

Cost Index – All costs were updated using the *ENR Construction Cost Index* of 6300, representing costs for June 2000. The costs for acquisition of land or easements were not included for any of the engineered or riparian enhancement alternatives.

Provisions for Engineering, Administration, and Contingencies – Other project costs have been assumed to be equal to 45 percent of the construction costs of the project. This includes 20 percent for engineering, 5 percent for administration, and 20 percent for contingency. The same percentage was assumed for both engineered and restoration projects because, although the restoration projects typically involve less engineering, they require a large permitting effort.

3.6 IMPLEMENTATION STRATEGY

A strategy for implementing improvements was developed for each watershed. The strategy was based on a combination of four categories of activities, including capital projects, maintenance activities, policies, and community involvement. Each category is described below.

- **Capital Projects** – Capital projects include structural solutions to stormwater runoff, such as pipes, bridges, culverts, stream restoration, streambank stabilization, detention ponds, and swales.

- **Maintenance Activities** – City maintenance activities can address a number of flow and water-quality-related problems. The City can provide personnel and equipment for manual and machine-assisted removal of debris and sediment from channels, pipes, and culverts; alter street sweeping and catch basin cleaning activities; and take other measures.

- **Policies** – Upon its adoption, the SWMP, including the policies in Chapter 5, will become an amendment to the City of Corvallis Comprehensive Plan. Selected policies from the SWMP will also be added to appropriate sections of the Comprehensive Plan.

- **Community Involvement** – Community members can be involved in a number of activities that improve stream and riparian habitat conditions, such as educating the community and participating in volunteer activities for restoring or enhancing the watershed. Activities can be implemented by community groups, neighborhood associations, schools, scout troops, and stream associations.

The strategy for each watershed basin was divided into two levels of implementation: Short-Term Program and Long-Term Program. Each level of implementation is described below.

- **Short-Term Program** – Identifies the immediate needs of the stormwater system within each watershed and implements improvements over an approximate 10-year period. Improvements are implemented when funding and resources are available, and generally result in the highest benefit with the least amount of cost.

- **Long-Term Program** – Represents projects to further protect and restore the health of the watershed that would be implemented over a longer time frame, generally upon complete implementation of the Short-Term Program. In some cases, long-term programs may be implemented concurrent with the Short-Term Program, especially when the implementation is staged over a long period of time.

3.7 RELATED REGULATIONS

Several federal and State regulations govern various aspects of local stormwater management activities. These include the National Pollution Discharge Elimination System (NPDES), Total Maximum Daily Load (TMDL), and the Endangered Species Act (ESA). Each regulation addresses a different aspect of stormwater management and must be incorporated into a comprehensive management plan.

3.7.1 National Pollution Discharge Elimination System

The authorizing legislation for municipal stormwater management is the 1987 federal Clean Water Act (CWA) amendments. They provide for municipal discharge permits to be issued on a system-wide basis. Through this legislation, the NPDES requirements were expanded to include the regulation of stormwater discharges. Cities that discharge treated wastewater to a waterway currently operate wastewater treatment facilities under an NPDES discharge permit. Companies that discharge stormwater from industrial sites also receive permits under these requirements. Operation of a municipal separate storm sewer system (MS4) requires an NPDES permit. Agricultural stormwater is not currently managed by NPDES.

National stormwater permitting was initiated by the NPDES Phase I requirements promulgated in 1990. Phase I requirements focused on cities with more than 100,000 people, industrial facilities, and construction sites that disturbed 5 acres or more land. The Phase II requirements published in December 1999 extended the permitting to include "small" cities and construction sites that disturb lands from 1 to 5 acres. Corvallis is included in the Phase II permitting.

Regulations issued to implement the MS4 permitting system prohibit non-stormwater discharges to storm drains and require controls to reduce the discharge of pollutants from storm drains to the maximum extent practicable. The discharge of pollutants to storm drains is a largely urban non-point source pollution problem that is to be addressed by structural and non-structural improvements and activities. Rather than setting numerical effluent limits, the regulations encourage the management of stormwater through Best Management Practices (BMPs). BMPs aim to reduce erosion, manage chemicals, remove pollutants through maintenance practices including street sweeping, and educate the public in behaviors that place water quality goals at risk.

Specifically, the NPDES Phase II requires implementation of six minimum control measures. The rules require the permittee (i.e., the City) "to identify and submit to the NPDES permitting authority a list of BMPs that will be implemented for each minimum control measure. They also must submit measurable goals for the development and implementation of each BMP" (Federal Register, 1999). "In other words, EPA would expect Phase II permittees to tailor their stormwater management plans and their BMPs to fit the particular characteristics and needs of the permittee…." In addition, the permittee must show a schedule for implementing the program and definition of entity responsibility.

The six minimum controls with examples of appropriate BMPs are as follows:

1. **Public Education and Outreach** - Distribute brochures, flyers, or bill inserts to educate homeowners and business operators about the problems associated with stormwater runoff and the steps they can take to reduce pollutants in stormwater discharges.

2. **Public Participation/Involvement** - Provide notice of stormwater management plan development and hold meetings at which citizens and business operators are encouraged to communicate ideas. Include citizen and business representatives in a Citizens' Advisory Group.

3. **Illicit Discharge Detection and Elimination** - Inventory and map the stormwater system and test for the possible cross-connections of sanitary wastewater to the stormwater conveyance system. Modify system to eliminate illicit discharges.

4. **Construction Site Runoff Control** - Require the implementation of erosion and sediment controls, and control other waste. Review site plans and perform periodic inspections. Establish penalties for non-compliance.

5. **Post-Construction Runoff Control** - Require the consideration and implementation of post-construction stormwater controls for any new construction. This might include on-site detention, pollutant reduction, or both.

6. **Pollution Prevention/Good Housekeeping** - Train maintenance staff to employ pollution prevention techniques and to maintain and operate public facilities to ensure the most efficient pollutant reduction. Materials handling, fleet vehicle maintenance, and application of chemicals in public areas, such as parks and roadways, should be managed to reduce impact on stormwater quality.

The Oregon Department of Environmental Quality (DEQ) is the NPDES permitting authority in the state of Oregon. The DEQ will be writing the Phase II NPDES permits with review and required approval from the EPA. The City will be required to submit a permit application or Notice of Intent by March 2003. The City must fully develop and implement a program within 5 years of issuance of the permit. Within the planning period, it is anticipated that Corvallis will be large enough to qualify as an urban area and will be subject to Phase II evaluation. The DEQ has not yet completed the task of implementing all Phase II regulations.

3.7.2 Total Maximum Daily Load

The CWA requires that each state implement activities to protect the quality of its rivers, streams, and other water bodies. The DEQ has primacy for implementing this law, including the responsibility for developing standards to protect the beneficial uses that have been determined for each water body. The DEQ developed the 303(d) list to identify water bodies that do not meet current standards. Once a water body has been listed, local governments are responsible for working with the

DEQ to develop and implement recovery plans to protect the beneficial uses. See Table 3-3 for the Willamette River and Marys River sections listed by the DEQ.

The DEQ will develop Total Maximum Daily Load (TMDL) levels for each stream on the 303(d) list within 10 years of its listing. TMDLs define the quantity of pollutant that can enter a water body without violating water quality standards. TMDLs apply to both point (end of pipe) and non-point (stormwater runoff) sources, and include a factor of safety to account for uncertainty and allow for some future discharges into the water body. TMDLs have not yet been established for Marys River or the Upper Willamette Basin. The DEQ is scheduled to complete these by 2003. To date, a lack of resources has restricted the DEQ's ability to complete the necessary studies within the specified timeframe.

Table 3-3. DEQ 303(d) Listings

DEQ record ID	Boundary	Parameter/criteria	Basis for consideration
Willamette River (Upper Willamette Basin)			
5867	Calapooia River to Long Tom River	Temperature/rearing 64° F	Summer values exceed temperature standard 64° F.
6043	Calapooia River to Long Tom River	Bacteria/water contact recreation	12 percent of the samples exceeded fecal coliform standard (400 count/100ml)
7090	Calapooia River to Long Tom River	Toxics/tissue-mercury	Health Division consumption health advisory issued for mercury in fish tissue (0.63 ppm); reference level (0.35 ppm)
Marys River			
5920	Mouth to Greasy Creek	Temperature/rearing 64° F	Summer values exceed temperature standard 64° F.
6055	Mouth to Greasy Creek	Bacteria/water contact recreation	Values exceed fecal coliform standard (400 count/100 ml) with a maximum value of 2,400 count/100 ml
6300	Mouth to Greasy Creek	Flow modification	Low flows have been suggested as cause of cutthroat population decline

Once TMDLs have been established for a water body, the DEQ will require the preparation of a comprehensive watershed plan that will define how the water body will be brought into compliance with water quality standards. The plan must address all activities within the watershed that could impact water quality, including industrial and municipal treatment facility discharges, agricultural and irrigation flows, stormwater runoff, construction site erosion, streambank shading, and land development methods. In addition, the plan must be prepared in accordance with federal and State laws.

3.7.3 Endangered Species Act

The Endangered Species Act (ESA) was enacted to prevent extinction of certain species of fish, wildlife, and plants that have seen significant declines in their populations within a defined geographic range or Evolutionarily Significant Unit (ESU). The rules prohibit a "take," which the ESA defines as "harass, harm, pursue, hunt, shoot, wound, trap, capture, or collect, or attempt to engage in any such conduct." The rules go into effect immediately upon listing by the government. The term "harass" is further defined as any intentional or negligent act that creates the likelihood of injuring wildlife by disrupting normal behavior such as breeding, feeding, or sheltering, whereas "harm" is an act that either kills or injures a listed species. By definition, "take" and "harm" can include any habitat modification or degradation that significantly impairs the essential behavioral patterns of fish or wildlife.

The National Marine Fisheries Service (NMFS), a section within the National Oceanic and Atmospheric Administration (NOAA), is responsible for administering the ESA rules as they apply to marine fish species. The U.S. Fish and Wildlife Service (USFWS) protects freshwater fish and all other animal and plant species.

ESA requirements apply to any activity that could result in a take of an endangered species. According to the NMFS, "Any government body authorizing an activity that specifically causes take may be found to be in violation of the Section 9 take prohibitions." Corvallis manages a number of activities that could potentially impact endangered species, including:

- Planning and zoning
- Development permitting
- Erosion and sediment control
- Floodplain management
- Water use
- Stormwater discharge
- Wastewater discharge
- Road and bridge construction and maintenance
- Pesticide, herbicide, fertilizer, and other chemical use
- Riparian area protection, alteration, or development
- Wetland protection, alteration, or development

In addition, NMFS and the USFWS have a policy to identify specific activities considered likely to result in take. As indicated in the *Federal Register* "Notice of Threatened Status for Two ESUs of Steelhead in Washington and Oregon" (U.S. Department of Commerce, March 1999), such activities include, but are not limited to:

1. Destroying or altering the habitat of listed salmonids (through activities such as removal of large woody debris or riparian shade canopy, dredging, discharge of fill material, draining, ditching, diverting, blocking, or altering stream channels or surface or ground water flow).

2. Discharging or dumping toxic chemicals or other pollutants into waters or riparian areas supporting listed salmonids.

3. Violating federal or State CWA discharge permits.

4. Applying pesticides and herbicides in a manner that adversely affects the biological requirements of the species.

5. Introducing non-native species likely to prey on listed salmonid species or to displace them from their habitat.

3.7.3.1 Enforcement

Enforcement of ESA rules will be by the NMFS under Section 9 of ESA. Also, third parties may bring suit under Section 9 against the entity or person alleged to have committed a take. A take permit or a 4(d) take limit is not required if a take does not occur. However, an entity or person will be at risk of violating the rules unless a certainty of compliance is provided as offered under Section 4(d), Section 10, or the federal nexus.

3.7.3.2 Listed Wildlife and Plants

Listings define the status of the species as endangered, threatened, or not warranted. Endangered is defined as, "in danger of extinction throughout all or a significant portion of its range," while threatened means, "likely to become endangered within the foreseeable future throughout all or a significant portion of its range." Two species of fish have been listed for the Corvallis area:

- Oregon Chub, Oregon ESU — Endangered
- Chinook salmon, Upper Willamette River ESU — Threatened

The USFWS has listed 28 species of plants and animals as endangered or threatened in Oregon. The City may request a report from the Oregon Natural Heritage Program that lists species identified in the Corvallis area. Regardless, the determination of whether any of the listed species are in a particular area is the responsibility of the owner/developer of the land. In addition, listings can change; therefore, it is imperative that the owner/developer of a property determine the applicable listings at the time of the proposed activity.

3.7.3.3 Complying with the Endangered Species Act

The final rules defining the NMFS requirements for conserving the listed steelhead and salmonid ESUs were published in the *Federal Register* on July 10, 2000. The discussion presented in this document is based on the final rules and on information gathered through discussions with the NMFS and others involved in the 4(d) exemption process. The final 4(d) rules for the different ESUs have different effective dates. The effective date for the salmon ESUs is January 8, 2001.

A number of jurisdictions, including Corvallis, are negotiating with NMFS to define the programs that would be required to provide eligibility for the 4(d) exemption. NMFS will apply the following 12 evaluation considerations when reviewing Municipal, Residential, Commercial, and Industrial (MRCI) development ordinances or plans to assess whether they adequately conserve listed salmonids by maintaining and restoring properly functioning habitat conditions:

1. Ensures that development will avoid inappropriate areas such as unstable slopes, wetlands, areas of high habitat value, and similarly constrained sites.

2. Adequately avoids stormwater discharge impacts to water quality and quantity or to the hydrograph of the watershed, including peak and base flows of perennial streams.

3. Adequately protects riparian area management requirements to attain or maintain properly functioning conditions (PFC) around all rivers, estuaries, streams, lakes, deepwater habitats,

and intermittent streams. Compensatory mitigation is provided, where necessary, to offset unavoidable damage to PFC due to MRCI development impacts to riparian management areas.

4. Avoids stream crossings by roads, utilities, and other linear development wherever possible. In addition, where crossings must be provided, minimizes impacts through choice of mode, sizing, and placement.

5. Adequately protects historical stream meander patterns and channel migration zones, and avoids hardening of stream banks and shorelines.

6. Adequately protects wetlands and wetland functions, including isolated wetlands.

7. Adequately preserves the hydrologic capacity of permanent and intermittent streams to pass peak flows.

8. Includes adequate provisions for landscaping with native vegetation to reduce the need for watering and application of herbicides, pesticides, and fertilizers.

9. Includes adequate provisions to prevent erosion and sediment runoff during construction.

10. Ensures that water supply demands can be met without impacting flows needed for threatened salmonids, either directly or through groundwater withdrawals, and that any new water diversions are positioned and screened in a way that prevents injury or death of salmonids.

11. Provides necessary enforcement, funding, reporting, implementation mechanisms, and formal plan evaluations at a minimum of every 5 years.

12. Complies with all other State and federal environmental and natural resource laws and permits.

The NMFS recommends a "plug and play" approach to meeting the 4(d) requirements. Jurisdictions would produce plans to be reviewed by the NMFS. If approved, the plans would be published in the Federal Register and made available for others to adopt. While adoption in this manner would save new applicants considerable time and effort in developing a compliance plan, the plan must still be tailored to meet the specific needs of the listed species within the applicant's jurisdiction. The NMFS must review and approve the modified plan before it can provide protection against take.

Although there is currently no prototype format for a stormwater management plan to serve as a 4(d) limitation on the take prohibitions, the NMFS is requesting that cities meet with them to discuss ways in which their programs can serve as an application for a 4(d) limitation on the take prohibitions. Other than applicable Section 7 consultation requirements, the NMFS does not have authority to require review of a city's stormwater management plan. However, receiving a limit on the take prohibitions under section 4(d) would provide legal assurance to the City that it would not be subject to an NMFS enforcement action or a third-party lawsuit.

3.7.3.4 Corvallis Endangered Species Act Planning

The City is undertaking a separate work effort to address the community's response to the Endangered Species Act. The work consists of collecting data, conducting inventories, and applying scientific methods to evaluate fish habitat impacts. Options and strategies will be developed to prevent further habitat degradation. Results of this effort may coincide with many of the recommendations contained within this document.

3.7.4 Floodplain Management

Congress initiated the National Flood Insurance Program (NFIP) in 1968 to control costs to all levels of government due to flood disaster relief. The Federal Insurance Administration, part of the Federal Emergency Management Agency (FEMA), administers the NFIP. The NFIP insurance coverage is available only in communities that implement regulations to reduce the likelihood of future flood damage. Zoning laws, building codes, and development regulations serve to manage the floodplain by setting restrictions and requirements for new construction within flood-prone areas.

Congress modified NFIP in 1973. Funds related to federal programs that involve structures within the 100-year floodplain can be granted only if the structure is covered under a flood insurance policy and the community participates in the NFIP.

The National Flood Mitigation Fund was set up by the FEMA as the result of 1994 legislative reforms. The FEMA can fund planning and actual projects on a cost-sharing basis of 25 percent state and local funding and 75 percent federal funding, contingent on the development of a flood mitigation plan.

Current FEMA regulations define two flood zones:

> **Floodway** – Part of the 100-year floodplain that must be kept clear of fill or other obstructions to convey the 100-year flood without an excessive increase in flood elevations
>
> **Floodway fringe** – Portion of the 100-year floodplain outside of the floodway. This may be developed if the fill does not cause the 100-year flood elevation in the floodway to rise more than 1 foot.

Corvallis has its own definition for floodway and floodway fringe. See section 5.4.5, Floodplain Management, in Chapter 5.

To enter the regular NFIP program, a community must complete a detailed technical study of flood hazards. A floodplain study determines the elevations of floods of varying intensity and the floodway boundaries. This information is presented on a Flood Insurance Rate Map and Flood Boundary and Floodway Map. The community adopts and enforces regulatory standards based on these maps.

Physical data developed as part of the SWMP's hydrologic/hydraulic modeling could be used to update or develop FEMA maps. However, most master planning efforts do not provide the level of technical analysis required to satisfy the FEMA requirements. As part of a FEMA update, maps could be developed that account for planned improvements to the stormwater drainage system. This could be advantageous to the community if the actual 100-year floodplain is less extensive than currently shown on FEMA maps, resulting in a reduction in the area that is impacted by FEMA requirements.

3.7.5 Wetland Management

Section 10 of the Rivers and Harbors Act of 1899 requires approval prior to work in or over "navigable waters" of the United States, or to work that affects the course, location, condition, or capacity of such waters. The U.S. Army Corps of Engineers (COE) is responsible for administering the Act. By definition, the wetlands and streams in and around Corvallis are covered by this requirement. Typical activities requiring Section 10 permits are:

- Construction of piers, wharves, bulkheads, marinas, ramps, floats, intake structures, and cable or pipeline crossings.
- Dredging and excavation.

Section 404 of the CWA requires approval prior to discharging dredged or fill material into the "waters of the United States." The COE is also responsible for administering Section 404 of the CWA. Again, "waters of the United States" includes essentially all surface waters such as all navigable waters and their tributaries, all interstate waters and their tributaries, all "wetlands adjacent" to these waters, and all impoundments of these waters. Typical activities requiring Section 404 permits are:

- Depositing of fill or dredged material in waters of the U.S. or adjacent wetlands.
- Site development fill for residential, commercial, or recreational developments.

As defined in Section 404, wetlands are:

> Those areas that are inundated or saturated with surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

In addition to the COE, the Oregon Division of State Lands (DSL) regulates activities in wetlands. The primary state regulation that affects development activities in and near wetlands is the Removal-Fill Permit Program, ORS 196.800 through 196.990, administered by the DSL. The DSL uses the 1987 COE manual to delineate wetlands.

The Removal-Fill Permit Program regulates:

- The removal of 50 cubic yards or more of material from one location in any calendar year.
- The filling of a waterway with 50 cubic yards or more of material at one location at any time.

The DSL also regulates irrigation ditches and intermittent streams if they are considered a source of food for wildlife or provide habitat for game fish. Further, the DSL regulates intermittent streams if they meet federal wetlands criteria.

Any public or private project that involves filling or removing fill from wetlands included in the Corvallis wetland inventory requires a DSL permit if the quantities exceed 50 cubic yards. The City's Wetland Factors Map identifies hydric soils (often a wetland indicator) and National Wetland Inventory wetlands. In addition, the City has conducted basin-wide wetland inventories for Squaw Creek, Jackson Creek, and Frazier Creek. The basin-wide inventories identify the probable wetland locations. The absence of wetlands, streams, and drainage channels on inventory maps does not automatically relieve the owner or developer of acquiring permits. Wetlands can be present on a site and not appear on an inventory map. The owner or developer must determine if wetlands are present and determine whether a DSL permit is required.

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

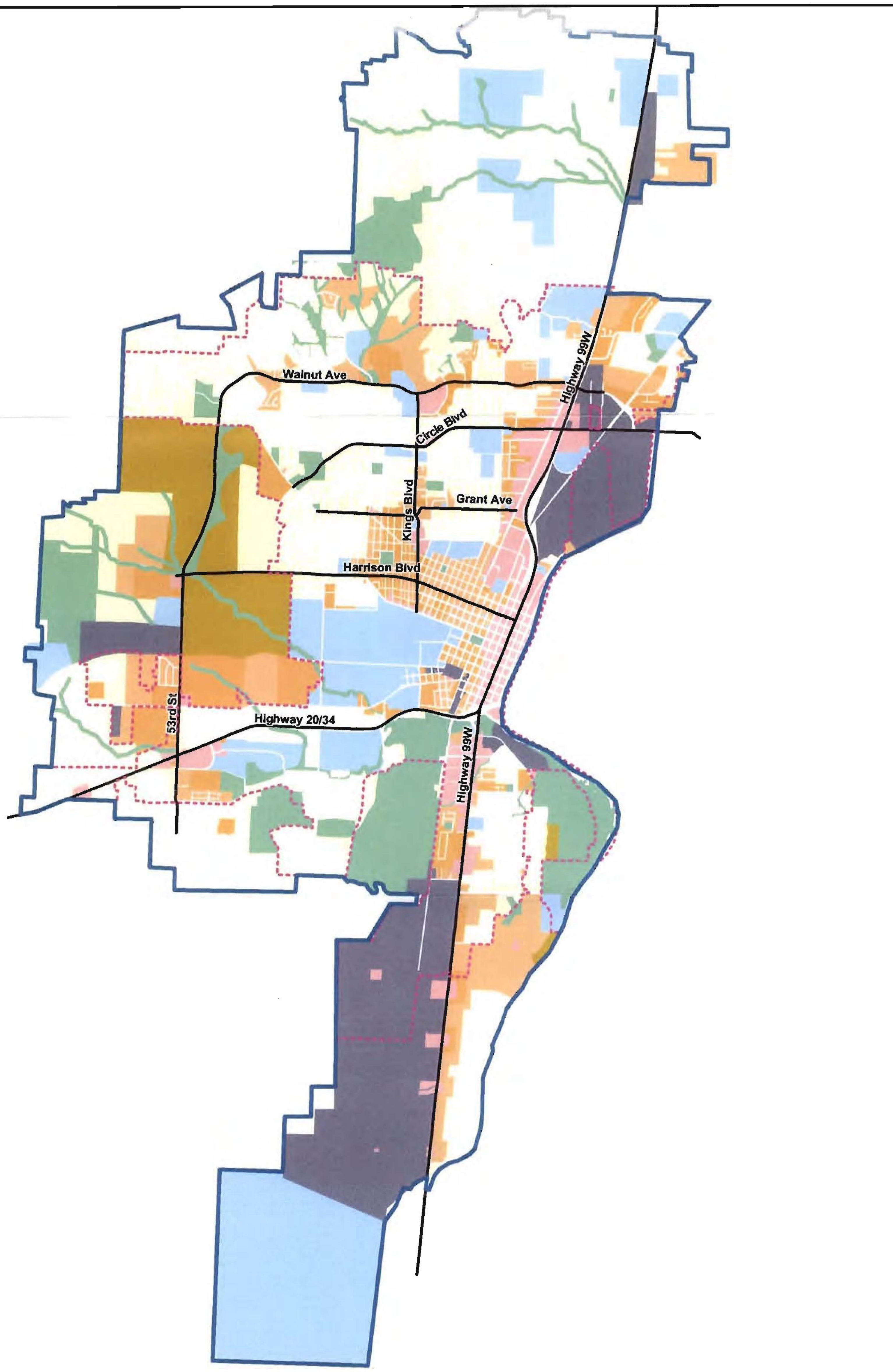


Figure 4-2 Projected Future Land Use

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
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.

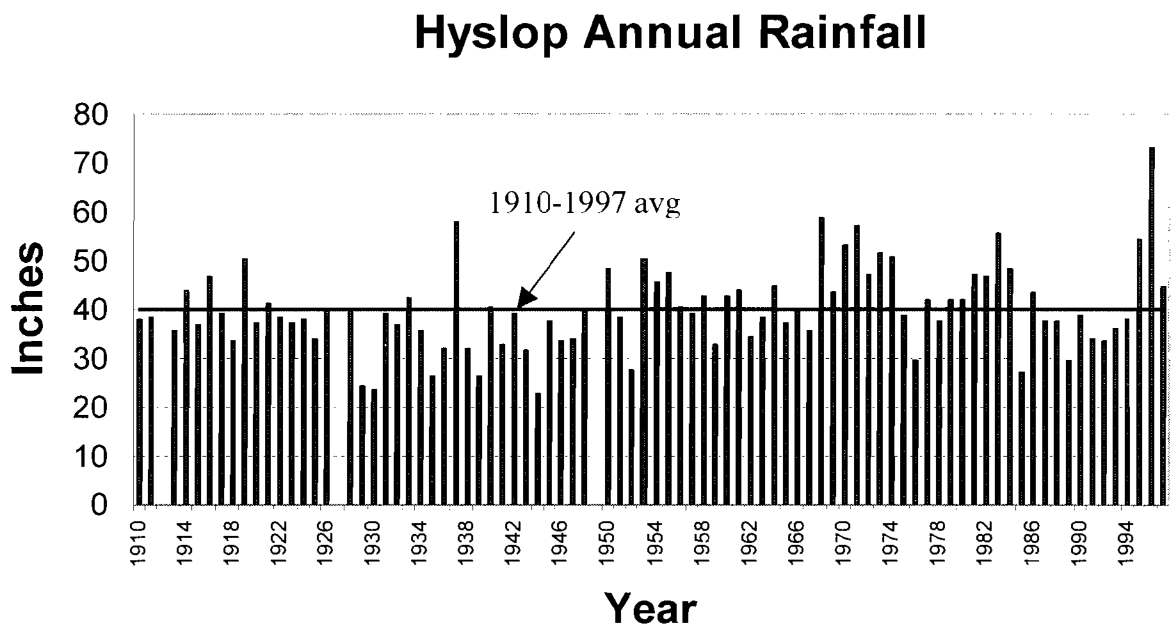
Table 4-4. Climate Statistics for Hyslop Field (1961-1990)

	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

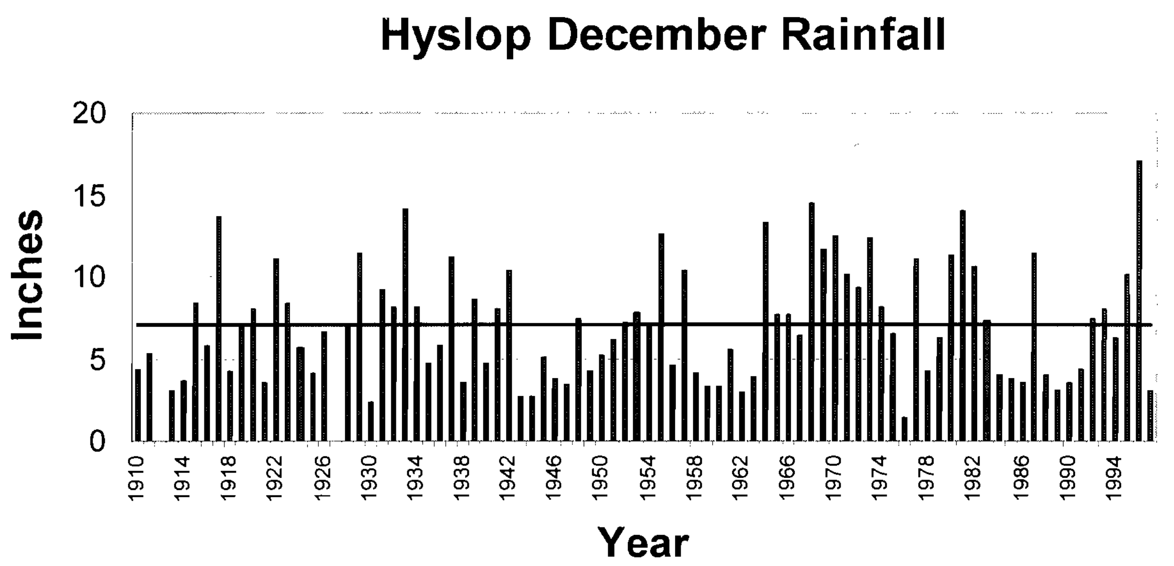


These long-term trends generally coincide with river and stream flows. However, short-term variations in the weather also play a significant role. For instance, in 1964 (the year of a severe flood event), the annual rainfall was 44.7 inches, only slightly above the long-term average of 40.1 inches. Figure 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 co-ordination 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.

CHAPTER 5

COMMUNITY-WIDE STORMWATER PLANNING AND POLICIES

5.1 INTRODUCTION

The Stormwater Master Plan (SWMP) is a departure from historical methods of dealing with stormwater runoff. It integrates the broader watershed and its functional elements and processes into stormwater planning and implementation. Streams that were viewed solely as water conveyance systems are seen as an integral part of the community's ecological health. A watershed is defined as the land within a given area (or basin) that collects rainfall towards a stream system. It includes the area from the ridge top of elevated areas to the confluence (or discharge) of the receiving stream, and both surface and subsurface water. The watersheds included in the SWMP are shown in Figure 4-1.

Planning by watershed is intended to provide a unified stormwater management strategy that will address water quality, water quantity, uplands natural resource and wetlands management, cross-jurisdictional basin management, floodplain management, and stream-system management. Public participation and information outreach are also important components of a community-based management process.

This chapter identifies stormwater-relevant findings, including state and federal regulatory guidelines, current City practices, and community values. Based on these findings, it provides stormwater policy direction, and describes strategies and practices for managing local streams and watersheds. The chapter is organized into the following sections:

Background - Provides the context of Corvallis stormwater management, including streams and the way in which the community would like to address stormwater management today.

Existing Planning Framework - Summarizes other City documents related to stormwater planning, policy, and implementation.

Stormwater Quality Management - Addresses stormwater quality issues, including pollutants in surface and ground water, sediment transport, and water temperature.

Water Quantity Management - Addresses how stormwater volume is managed within the Corvallis urban landscape, from rainfall and other sources, to the stormwater's ultimate discharge.

Uplands Natural Resource and Wetlands Management - Addresses the stormwater management values of uplands natural features and wetlands, and the implications of activities in these areas.

Cross-Jurisdictional Basin Stormwater Management - Addresses watershed issues that cross-jurisdictional boundaries, including flow, water quality, wetlands, and stream vitality.

Floodplain Management - Addresses the functional value of floodplains and the implications of encroachment into them, and provides guidance for activities within floodplains.

Stream System Management - Addresses various techniques available for managing streams and riparian areas.

Public Participation and Information Outreach - Describes what can be done to involve and inform the community about individual and community-wide practices to improve stormwater management, including water quality, detention, and stream health.

Process for Implementing Policy Recommendations - Includes specific recommendations on implementation of this chapter's policy recommendations.

5.2 BACKGROUND

Like many northwest communities, Corvallis initially collected urban runoff and domestic sewage in the same piping system, called a combined sewer. The combined wastewater was then piped directly into the Willamette River. The City's first wastewater treatment system was constructed in 1952. The original facility had limited capacity and, by today's standards, the wastewater received little or no treatment, depending on rainfall intensity. As the river became increasingly polluted, the need for more intensive treatment of domestic and industrial wastes was met with sophisticated biochemical treatment. The cost per gallon of such treatment was expensive and it became economically prohibitive to continue treatment of storm runoff. Corvallis embarked on a program of sewer-storm separation, dedicating much of its combined sewer system exclusively to domestic waste, and routing stormwater to nearby drainageways or native streams.

When Corvallis introduced system development charges (SDCs) in the 1970s, stormwater conveyance was excluded. This decision marked the end of publicly funded stormwater pipes. Since that time, Corvallis has become increasingly dependent on its native streams and drainageways for conveyance of urban runoff. In 1981, Corvallis formally acknowledged that streams had, in fact, been transformed into the principal stormwater conveyance system, resulting in the City's first Stormwater Master Plan.

In the recent past, urban streams were managed solely as stormwater conveyance systems. This approach led to a decline in stream water quality, loss or decline in the diversity and abundance of aquatic and riparian species, and degradation of the physical condition of streams. It is now understood that, if managed appropriately, the streams passing through a city can provide numerous amenities to the community, including natural hydrological management such as the reduced potential for flooding, protected or restored habitat for aquatic and riparian species, improved water quality, green belts, open spaces, educational opportunities for citizens, and increased property values for abutting property owners.

In the early 1970s, the State and federal governments established regulations protecting wetlands and the water quality of streams. Although these regulations were responsible for a number of improvements, the health of local waterways continued to degrade. Recently, new federal regulations were adopted to help further protect and improve streams, rivers, wetlands, and other natural habitats of our community. These new regulations require that local governments take a more active role in protecting water quality and certain species of fish and wildlife, and their habitats.

The City determined that the community was interested in updating the Stormwater Master Plan. In response to this concern, the Mayor appointed a Stormwater Planning Committee (SWPC) to work with the citizens and public agencies to undertake this effort. A variety of citizens provided direction on issues related to local stormwater management during the development of the SWMP. An initial random telephone survey (366 respondents) and stakeholder interviews (50 respondents) were conducted to assess citizen attitudes and values on elements of stormwater management. The respondents placed a high priority on improved stormwater management, such as better water quality, flood mitigation, wetland protection, and stream corridor vitality. The survey and interview questions, along with the results of both, are in Appendix A.

Additional citizen input was collected through a series of community public meetings and workshops hosted by the SWPC. The first three meetings focused on collecting citizens' issues, values, and objectives, and developing a set of stormwater evaluation criteria, which became the guiding principles for stormwater management. Citizen input was also collected for each basin within the Urban Growth Boundary (UGB) during a series of 10 meetings hosted by the SWPC. Two workshops were then held to collect citizen input specific to watershed management, including alternatives for floodplain regulations and stream corridor width, water quality, detention, and stormwater management from a watershed-wide perspective.

The comments and responses of citizens were reviewed by the SWPC to identify specific stormwater policy issues. The SWPC considered a range of policy alternatives to address these issues. The stormwater policy direction and suggested strategies and practices in the SWMP are a result of this community-wide process. The results of the public meetings and the policy alternatives considered by the SWPC are summarized in Appendix A.

To meet regulatory requirements and address citizen input, a watershed-based approach to stormwater management was used. This approach considers the diverse needs of the community, government regulations, and environmental implications. The City is in a unique position to provide watershed management leadership, since the City is responsible for numerous activities that affect the health of the watersheds. The City and the community acknowledge that this approach is necessary and, through the implementation of the SWMP, intend to preserve and restore these watershed functions for the benefit of current and future generations.

Community outreach efforts were conducted to develop a set of criteria by which the SWPC could evaluate the various options being considered. The following criteria were established and used in their evaluation of these options. Examples to aid in the clarification of these criteria are in Appendix A.

- Maintains and accommodates natural hydrological processes.
- Protects and improves water quality.
- Controls unwanted erosion.
- Protects and restores natural resources and ecosystem functions.
- Meets or exceeds current regulations and anticipated future regulations.
- Ensures that cost considerations are inclusive.
- Addresses maintenance requirements and allows for maintenance access.
- Incorporates community awareness and information exchange.
- Addresses cumulative effects and off-site effects.
- Is designed and managed to avoid public health and safety hazards.
- Incorporates community amenities.

- Explores and uses innovative and low-technology approaches.
- Implements urban and rural land use objectives.

A significant portion of development within the Corvallis UGB results from public activities such as infrastructure development and building construction. Through infrastructure planning and construction, the City influences the locations of other public and private developments. For example, when a road is planned and built within a floodplain, the City encourages other construction within that floodplain.

The City has the opportunity to provide leadership by using highly responsible standards for its municipal development activities. The City can use its partnerships with other public entities, such as the county and school district, to encourage these public bodies to exhibit the same responsible activities in their construction, operation, and maintenance tasks. Policies outlined in the SWMP will apply to municipal as well as residential, industrial, and commercial development. The City will use its facility plans to provide the framework to encourage appropriate development in locations so as to preserve or enhance the flow and quality of the stormwater in its local watersheds.

5.3 EXISTING PLANNING FRAMEWORK

The SWMP provides the guiding framework and policy recommendations for managing watersheds and their associated waterways. The City also has a number of existing planning and engineering tools available for managing stormwater runoff and natural resources within the community. These tools include:

- Comprehensive Plan,
- Master Plans,
- Land Development Code,
- Municipal Code,
- Council Policy,
- Design Criteria Manual, and
- Standard Construction Specifications.

The relationships among these documents are described in the next sections. Altogether, these documents provide the City with the framework for managing stormwater and watersheds.

5.3.1 Comprehensive Plan

The Comprehensive Plan contains the requirements of the Statewide Planning Goals and Guidelines and the community's vision on land use. It defines how land will be used and managed within the City.

Generally, the Comprehensive Plan is organized around the topic areas defined by the Statewide Planning Goals. Each topic area is in an article (chapter) that includes a background discussion followed by findings and policies in support of the goals. The findings provide statements of fact or conclusions, while the policies provide guidance for actions required for meeting the community's vision. Master facility and area-specific plans for implementing the policies of the Comprehensive Plan are also included by reference as part of the Plan.

5.3.2 Master Plans

The City has developed master plans that address long-range planning within specific areas of service or interest. These master plans add greater detail to the policy direction provided by the Comprehensive Plan. For example, the *South Corvallis Drainage Master Plan* (SCDMP) was developed to address the specific drainage needs of that area of the City.

Other planning documents that influence stormwater and natural resource management include: South Corvallis Area Plan, West Corvallis/North Philomath Plan, Parks and Recreation Facilities Plan, Criteria and Process to Acquire or Protect Open Space, Water Master Plan, Wastewater Master Plan, and the Corvallis Transportation Plan. Since each of these documents was prepared with a different primary purpose, their effect on stormwater and natural resource management may not be consistent with contemporary watershed management.

5.3.3 Land Development Code

The Land Development Code (LDC) provides specific direction to implement the policies of the Comprehensive Plan and the associated Master Plans. It is one of several documents used by developers, interested citizens, and the City to ensure that new construction and redevelopment are consistent with the goals and policies of the City. It contains development standards for various land use designations, along with the legal framework, enforcement provisions, and administrative procedures for land development.

5.3.4 Municipal Code

The ordinances defined by the Municipal Code provide the legal framework for managing City operations and define procedures and responsibilities for many of the activities undertaken by City government. The Code contains sections on local improvements, utilities, traffic, public protection, and development regulations. Presently, the section on utilities focuses on the sanitary collection/treatment and water distribution systems. The Code is silent on stormwater management issues, except for title 2.09, which explains the financial charges for the stormwater utility.

5.3.5 Council Policy

As the City's governing body, the City Council uses numerous avenues to define policies. These avenues include special plans developed in response to specific needs, such as an Endangered Species Act (ESA) Response Plan, budget authority as exercised through the annual City budget and the Capital Improvement Plan, and agreements with other jurisdictions governing joint activities. The Council can also develop policies that provide direction for the day-to-day operations of City government, such as maintenance procedures, recycling, and chemical use in landscaping. Examples are the Drainageway Maintenance Plan and the Integrated Pest Management Plan.

5.3.6 Design Criteria Manual

The 1991 Design Criteria Manual defines minimum engineering criteria for the design of public infrastructure including streets, and water distribution, sanitary sewer collection, and stormwater collection systems. For example, it specifies that new storm drains shall be designed to handle a 10-year event storm.

The Design Criteria Manual discourages the use of detention facilities, although the City has required their use in recent years for private development projects. In addition, the manual does not specify the use or design of facilities to protect water quality. Currently, the manual states that inspection and maintenance of private stormwater detention and treatment facilities are the responsibility of the owner(s).

Brown and Caldwell wrote an Interim Technical Memorandum, *Recommendations to Development Standards*, June 15, 1999, that specifically addresses new stormwater design practices. The memorandum discusses the rationale for modifying sections of the Design Criteria Manual and provides recommended language that could be adopted for it. The recommendations include requirements for detention and water quality facilities. This technical memorandum is in Appendix F.

5.3.7 Standard Construction Specifications

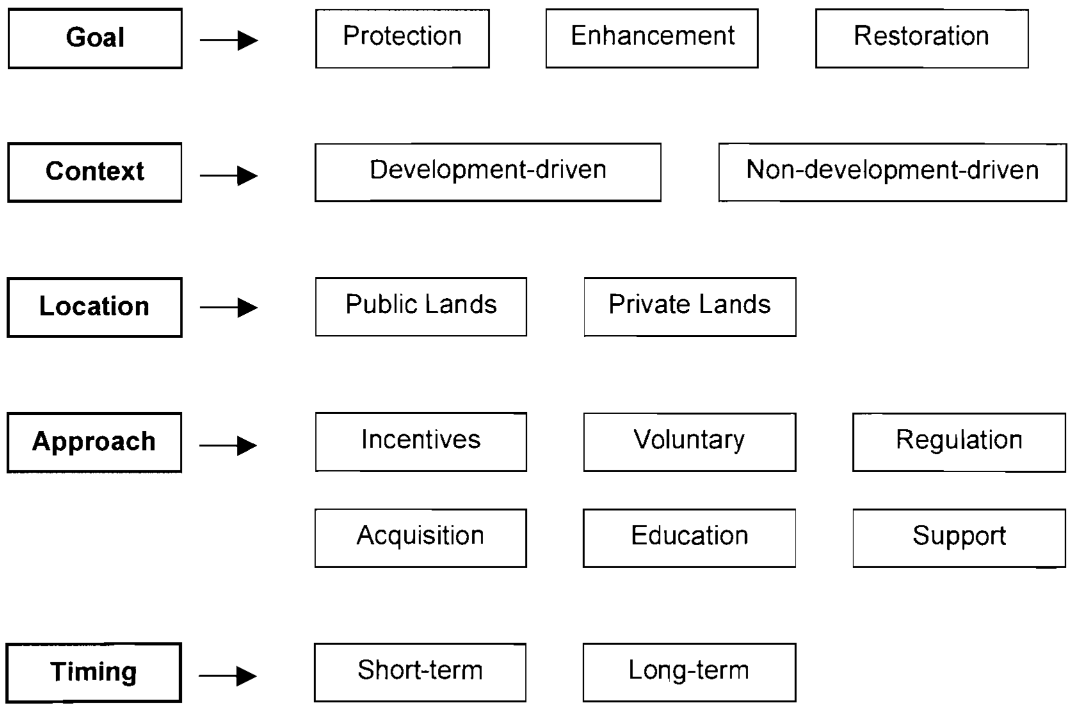
The Standard Construction Specifications (SCS) provide guidance on the design and construction of all public works projects within the City, including streets, sanitary sewers, water lines, and storm drainage systems.

5.4 WATERSHED AREA STORMWATER MANAGEMENT

In the following sections, each management issue is discussed in detail and includes background, issues, and citizen input that frame solutions to watershed management goals. These are followed by strategies to address the issues and specific policies and programs suggested to improve stream functions and stormwater management. This section also includes suggested follow-up actions that will be required to more fully address the issues.

Figure 5-1 summarizes the options and implementation strategies that were considered during development of the plan and the policies.

Figure 5-1. Stormwater Policy and Implementation Strategies



5.4.0 General Policies

GP-1 The Corvallis stormwater utility shall incorporate existing natural features such as streams and wetlands as a means of managing urban runoff. When using these natural features for urban stormwater needs, stormwater management shall follow the guiding principle of minimizing harm to these natural systems, maintaining the natural functions and, over time, repairing any damage associated with past practices.

GP-2 Implementation of the Corvallis Stormwater Master Plan shall be guided by the following evaluation criteria:

a. Maintains and accommodates natural hydrological processes.
b. Protects and improves water quality.
c. Controls unwanted erosion.
d. Protects and restores natural resources and ecosystem functions.
e. Meets or exceeds current regulations and anticipated future regulations.
f. Ensures that cost considerations are inclusive.
g. Addresses maintenance requirements and allows for maintenance access.
h. Incorporates community awareness and information exchange.
i. Is designed and managed to avoid public health and safety hazards.
j. Incorporates community amenities.

k. Minimizes cumulative effects and off-site effects.
l. Explores and uses innovative and low-technology approaches.
m. Implements urban and rural land use objectives.

GP-3 Policies outlined in the SWMP shall apply to Municipal, Residential, Commercial, and Industrial (MRCI) development.

GP-4 The City shall recognize and use both short-term (up to 10 years) and long-term (10-100 years) implementation strategies to meet community stormwater objectives.

GP-5 The City shall develop a set of incentive mechanisms for potential use in implementing stormwater policies and encourage private property owners, non-profits, and other organizations to participate in their implementation.

GP-6 The City shall determine "beneficial uses" relevant to local streams within the Urban Growth Boundary and monitor whether these streams are meeting their beneficial uses.

5.4.1 Stormwater Quality Management

5.4.1.1 Background

Human activities can degrade water quality. Impervious surfaces such as roads and parking lots collect oils and other materials that are transported into streams during rainstorms. Farming and development activities disturb historical vegetative cover, often resulting in the transportation of sediments into waterways. The application of chemicals by farmers and homeowners has also affected the chemistry of the water in the streams.

Corvallis citizens highly value the health of the City's streams, wetlands, and groundwater. In addition, a number of State and federal regulations were developed to improve or protect the quality of stormwater runoff and receiving waters. The Oregon Department of Environmental Quality (DEQ) has conducted studies and analyses that identify elevated temperature levels or concentrations of bacteria and toxins in Oregon streams and rivers. The DEQ has determined that the Corvallis section of the Willamette River is "water-quality limited" for temperature, bacteria, and mercury. (Water-quality limited streams do not meet water quality standards for a particular parameter such as mercury.) The Marys River near the confluence of the Willamette is water-quality limited for temperature and bacteria.

There has been limited testing for contaminants in Corvallis streams, but City data have shown periodic elevated temperature and bacteria levels. For these reasons, stormwater quality is one of the important issues that must be addressed in the stormwater planning process. For example, a recent National Water Quality Assessment Program study (Anderson, 1997) showed high levels of pesticides in Dixon Creek.

The City does some stream monitoring that includes monthly sampling and testing for basic water quality parameters including bacteria, dissolved oxygen, pH, and temperature. The principal goal of the stream monitoring program is to identify sources of contamination in urban streams. When sources of contamination are located, City staff conducts follow-up activities to facilitate elimination.

A 3-square-mile area within the City limits has a combined sanitary and stormwater collection system that conveys stormwater runoff to the wastewater treatment plant. The combined system serves some of the more densely developed and impervious areas of the City, including the downtown area. The stormwater collected in this area is treated to remove oils, grease, and suspended solids, and is chlorinated and then de-chlorinated. This level of stormwater treatment exceeds all present state and federal regulations as well as the National Pollutant Discharge Elimination System (NPDES) Phase II Stormwater Regulations.

The Oregon DEQ issues erosion control permits for construction activities on sites greater than 5 acres. The City also has regulations and requirements to control erosion from construction activities. City staff is responsible for review and approval of erosion control plans, issuance of permits, and monitoring and enforcement compliance. The objective of the erosion control permit program is to prevent construction activities from negatively affecting stormwater quality and natural resources.

The City has on-going maintenance activities that protect stormwater quality. All City streets are swept bi-weekly and catch basin sediments are removed yearly to help prevent pollutants and sediments from reaching streams.

5.4.1.2 Issues

By the year 2006, existing State and federal regulations will require greater levels of stormwater pollution source-control and prevention for the area of the City that currently has separate sanitary and stormwater collection systems. The types and levels of pollutants in urban stormwater and streams were well documented by studies of urban areas in Oregon. The Association of Clean Water Agencies (ACWA) is an organization of municipalities that shares common water quality goals in Oregon; the City of Corvallis is a member. In 1996, ACWA surveyed member-agency stormwater quality monitoring data to develop a profile of "typical" urban stormwater pollutants. The results of this survey were incorporated in the DEQ stormwater quality management regulatory programs and recommendations of Best Management Practices (BMPs) to control stormwater pollutants.

The federal Clean Water Act is the basis for most water-quality related legislation, including the National Pollution Discharge Elimination System (NPDES) program and the State-implemented Total Maximum Daily Load (TMDL) requirements. The City is considering additional water-quality related requirements as part of the Endangered Species Act (ESA) to protect federally listed aquatic species in the Willamette Basin. Each of these regulations is discussed in detail in Chapter 3.

The City will be required to establish programs and resources to meet the NPDES Phase II Stormwater permit requirements on or before 2006. The NPDES Phase II program requires six minimum controls for Phase II permittees. Three of the controls directly affect stormwater quality: illicit discharge detection and elimination, construction site runoff control, and post-construction runoff control. As a Phase II permittee, the City is required to develop and implement BMPs that satisfy each of these minimum control measures.

The State TMDL requirements are specific to certain water-quality related parameters or criteria. For example, stream temperatures are elevated during the summer and exceed water quality standards in sections of the Willamette River and in the lower reaches of the Marys River. Bacteria in the Willamette River exceed standards, and elevated concentrations of mercury have been found in fish tissue. Each of these parameters has made the DEQ 303(d) list. The 303(d) list is part of a national EPA program to identify water-quality limited waterways and the pollution components that affect water quality, such as phosphorus, ammonia, and nitrates. The City must work with the DEQ to develop and implement a plan to restore and protect the beneficial uses of local streams and rivers.

Compliance with the ESA will affect many City activities, including public works projects and construction activities. Any activity that affects water quality and quantity, or the habitat of species listed under ESA, falls under the ESA requirements. Activities that result in erosion, use of chemicals (herbicides, pesticides, and fertilizers), and/or activities that affect riparian areas and wetlands must be scrutinized to determine the potential effects on listed species. Activities that have the potential to harm threatened or endangered species must be modified or eliminated. The City has initiated a separate work effort to determine the City's ESA Response Plan. Many elements of this SWMP were created with the ESA regulations in mind and will be an important component of the City's ESA Response Plan.

Although the City is responsible for complying with State and federal environmental regulations, private property owners are not always held to the same standards. Private property owners may affect streams or wetlands by encroachment, by removal of critical vegetation, or by the improper application of yard chemicals. These activities are often difficult to manage, as many citizens are not aware of the regulations that apply to their property, or are unaware of the detrimental effects that their activities have on a stream or wetland.

5.4.1.3 Citizen Input

Public input on policy development was received through public meetings held by the SWPC, a random telephone survey of residents, and stakeholder interviews. A telephone survey of 366 residents established a baseline of public opinion and identified public sentiment toward the management of stormwater in Corvallis. (See Appendix A for detailed survey results.) With regard to water quality, Corvallis residents clearly understand the importance of managing stormwater to protect the environment. Controlling surface pollutants entering streams received the highest "very important" rating (62 percent) of all issues reviewed, and a combined "very important" / "important" rating of 93 percent. Additionally, 52 percent of those surveyed say improving stream water quality is "very important" for future stormwater management planning, with a combined "very important"/ "important" rating of 92 percent.

Residents also consistently rate stream habitat as "very important." Fifty-six percent of those surveyed rate loss of stream habitat as "very important" with a combined "very important" / "important" rating of 88 percent. Sixty percent of the survey respondents say protecting stream habitat is "very important" in planning for future community stormwater management, with a combined "very important" / "important" rating of 94 percent. The importance of water quality is also underscored as residents rate less highly the option of using streams to drain urban runoff.

During public workshops conducted by the SWPC to develop stormwater alternatives, participants were asked to rate their support for water quality alternatives. Attendees were supportive of all alternatives that improved water quality. Over 80 percent of the participants supported voluntary measures and 70 percent supported mandatory standards. Participants supported alternatives to:

- Develop public infrastructure to provide for Best Management Practices for stormwater quality,
- Provide incentives to private construction that maintain stormwater quality, and
- Provide incentives to protect wetlands and riparian areas for their water quality benefits.

5.4.1.4 Strategies to Address Issues

The ACWA survey has been incorporated in the DEQ stormwater quality management programs and recommendations of Best Management Practices (BMPs) to control stormwater pollutants. BMPs include stormwater management techniques such as bioswales, surface detention ponds, and street sweeping. The City will be in compliance with NPDES Phase II regulations by applying the DEQ- recommended stormwater quality BMPs. The EPA has recommended BMPs for governing agencies to use for the control of stormwater quality issues for a range of contamination sources in the NPDES Phase II permit program. Additional, future water quality monitoring is recommended to confirm the success of stormwater quality BMPs.

Citizen interest in water quality and state and federal regulations suggest that the City would best meet the needs of the community by establishing policies to address state TMDL water quality standards for stream temperature and bacteria. Corvallis stream temperatures are monitored monthly, and exceed standards during the summer and fall when stream flows are low and ambient temperatures are hot. Direct sunlight on streams is a principal cause of increased stream temperatures and shading of the stream corridor is effective in controlling stream temperatures. Policies that support shading stream corridors are needed. Policies are also needed to support stream channel structure to create deeper pool habitat and provide cool refuge areas at times of low flows and warmer temperatures. Policies that promote groundwater contribution to base flows in streams and remove illicit stream flow diversions (typically for irrigation uses) will also help to control stream temperatures.

Bacterial contamination in streams can impair the safe use of the water body as a fishable and swimable stream. Policies that encourage BMPs for stormwater runoff that provide water quality treatment and reduced sedimentation will minimize bacteria in streams. Another common source of bacteria in streams is pet and other animal feces. Policies that control pet activities close to streams will address this source of bacteria. Policies should also address agricultural and other animal activities within or close to stream corridors. Controlling the sources of bacteria will reduce bacterial contamination of streams.

Another urban source of bacterial contamination is sanitary wastewater reaching streams via cross-connections between sanitary and storm systems. Operation and maintenance programs attempt to address elimination of cross-connections.

Compliance with NPDES Phase II and TMDL regulations will also assist the City in meeting ESA regulatory requirements. It is anticipated that the ESA Response Plan will require changes to City programs, operations and maintenance practices, maintenance standards, and development standards.

Protecting and improving the water quality of Corvallis streams represents an important value to the citizens of Corvallis. In response to the desires of the community, and as required by State and federal regulations, the SWMP establishes goals and policy recommendations to protect and improve stormwater quality. Also included are recommendations for follow-up actions.

5.4.1.5 Goals

1. Minimize soil erosion and sediment in stormwater.
2. Lower instream water temperatures.
3. Minimize pollution within waterways, groundwater, and wetlands.
4. Inform the public of the value of a healthy watershed.

5.4.1.6 Existing Policies

1. Where development of hillsides occurs, removal of vegetation will be minimized to control erosion. Vegetation disturbed during development shall be replaced or enhanced through landscaping (Comprehensive Plan Policy 4.6.9).
2. To minimize the negative impacts of development, stormwater runoff after development should be managed to produce no significant reduction of water quality than prior to development unless more appropriate provisions are identified in adopted comprehensive stormwater management plans (Comprehensive Plan Policy 4.10.6).
3. The City shall develop a program to minimize the conveyance of detrimental sediments and pollutants from public streets into streams and drainageways (Comprehensive Plan Policy 4.10.12).
4. The City shall attempt to protect groundwater resources from pollution and damage through education, regulation, and example (Comprehensive Plan Policy 4.12.1).
5. All development within the Corvallis Urban Growth Boundary shall comply with applicable State and federal water quality standards (Comprehensive Plan Policy 7.5.1).
6. The City shall work with the Oregon Water Resources Department to enforce illegal water withdrawals from streams (OWRD Regulation).

5.4.1.7 New Policies

QL-1 Sediment removal using Best Management Practices shall be used prior to discharge of all runoff from both public and private impervious areas.

QL-2 Lands set aside for water quality improvement, such as vegetated swales, detention facilities, and open channels, shall be maintained for proper functioning. Responsibility for maintenance shall be determined at the time these facilities are reviewed by the City for approval.

QL-3 To reduce the need for and costs associated with instream water quality monitoring, the City shall develop a program to monitor whether the stormwater quality policies are being implemented.

QL-4 The City shall develop a biological component for its instream water-quality monitoring program.

QL-5 The City shall work to ensure that harmful urban runoff is not discharged directly into streams.

QL-6 The City shall work to preserve and enhance native stream corridor vegetation on both public and private lands.

QL-7 The City shall work to limit stormwater pollutants from entering streams from sources such as agricultural waste, pet waste, vehicle wash water, household and business chemicals, and other community waste products.

QL-8 Along with the NPDES requirements, the City shall:

a. Require an erosion control plan for all construction activity that can potentially cause erosion.
b. Provide erosion control guidance to the development community in the form of an erosion control handbook.
c. Require sediment removal (to the maximum extent practicable) from construction site runoff prior to discharge to stormwater systems or streams.
d. Enforce erosion control measures through an active enforcement program with fines for violations, and educate the public and building inspectors on the importance of erosion control.
e. Develop community-specific standards that limit sediment discharge into receiving water bodies.

QL-9 The City shall develop guidelines for public agencies, private property owners, and landscape maintenance specialists that minimize the flow of chemical pesticides, herbicides, and fertilizers into the stream system.

QL-10 The City shall develop standards for cleaning publicly accessible parking lots and private catch basins that drain into public streams.

QL-11 The City shall continue cleaning public parking lots and catch basins.

QL-12 The City shall promote the protection of key areas of exchange between ground and surface waters, such as springs, unconstrained reaches of streams, and upstream drainages.

QL-13 The City shall prohibit new installations of overhead utility lines along streams where the utility is in conflict with management of vegetation that provides shading. However, utility lines may cross streams.

QL-14 The City shall promote the protection and enhancement of the stream channel structure for deeper pool habitat that provides cooler water refuge areas at times of low stream flows.

QL-15 The City shall continue to conduct cross-connection surveys to identify any sanitary or other illicit connections to the stormwater system.

QL-16 The City shall continue to evaluate, design, and modify its facilities to minimize known sources of water quality impairment.

5.4.1.8 Suggested Follow-Up Actions

1. The City shall investigate additional stormwater quality management techniques that are used by other agencies and implement them as appropriate.
2. The City shall retrofit catch basins to improve water quality.

5.4.2 Water Quantity Management

5.4.2.1 Background

Water quantity management addresses how stormwater is stored and conveyed from where it falls to where it ultimately is discharged into a receiving water body downstream of the City. Typically, with the current urban infrastructure, precipitation is managed in one of three ways: (1) It can travel overland as sheet flow to open-channel drainages, wetlands, or piped systems; (2) it can soak into the ground and, as subsurface flow, be intercepted and collected by sump pumps, tiling, etc., or migrate to an open channel; or (3) it can be intercepted and stored by vegetation, roofs, or other surfaces until it evaporates.

The open-channel systems include the numerous natural streams and manmade channels and ditches found throughout the City. The piped system includes the inlets, catch basins, and piped drainage system used to convey stormwater runoff.

The City operates and maintains the stormwater collection and drainageway system, and responds to emergency flooding issues, including capital improvement projects that address flooding concerns.

5.4.2.2 Issues

Flooding is a natural process that occurs in an open-channel system when the flow exceeds the hydraulic capacity of the channel and the floodplain is employed to temporarily store and transport this additional water. For flood policy and management purposes, this document distinguishes natural flooding from urban-created flooding. Natural flooding is typically the historical flooding patterns that occurred before the City was established. Natural flooding has many positive benefits, including creating and maintaining varied habitat for fish and wildlife, and transporting nutrients onto the floodplains.

Flooding can occur at natural and manmade constrictions, or be the consequence of higher flows associated with increased development and intensified by land uses that fill or isolate portions of the floodplain. Natural constrictions that can lead to site-specific flooding include debris jams, low channel gradients, and loss of channel cross-sections due to sediment buildup. However, channel structures such as wood jams create opportunities for temporary water storage within the stream corridor. Manmade constrictions within the natural channel systems are usually a result of undersized culverts or bridges, although other manmade structures such as utility piping and dams (for water extraction) can lead to backups and flooding. Shallow watercourses that have been channelized in low gradient areas can fill with sediment. For more discussion on flooding in natural channels, see Section 5.4.5, Floodplain Management, in this chapter.

Water quantity management in the piped system focuses on conveying and storing stormwater runoff with limited pipe surcharging and flooding. Surcharging is defined as water flowing under pressure and exceeding the normal carrying capacity of the pipe. Flooding occurs when surcharged water reaches ground level. Both surcharging and flooding occur when the flow exceeds the hydraulic capacity of the conduit due to undersized pipes, low gradients (pipe slope), downstream backwater effects, or a combination of these factors.

The primary regulations influencing water quantity management are the Endangered Species Act (ESA) and the National Flood Insurance Program (NFIP). For a complete overview of the applicable regulations, consult Chapter 3.

The ESA influences how stormwater is managed from a quantity perspective. To protect an endangered species, ESA requires that properly functioning conditions be maintained within the geographical range of the listed species. The National Marine Fisheries Service advises jurisdictions to evaluate how development will affect base and peak flows and to manage that development to avoid changing the natural stormwater runoff hydrograph.

Nationwide, the NFIP has a major influence on how water quantity and flooding are managed within urban areas. When Congress initiated the NFIP in 1968, its objectives were generally limited to controlling costs to all levels of government due to flood disaster relief. The NFIP did not (and does not currently) factor in erosion and sedimentation, hydrologic energy modifications, habitat implications, and isolation of citizens living in floodplain developments during an event. The NFIP is administered by the Federal Insurance Administration as part of the Federal Emergency Management Agency (FEMA). The NFIP insurance coverage is available only in communities that implement regulations to reduce the likelihood of future flood damage. Current building codes and development regulations conform to NFIP standards by restricting new construction within flood-prone areas to the floodway fringe (a subset of the floodplain).

To enter the NFIP program, a community must complete a detailed technical study of flood hazards. A floodplain study determines the elevations of floods of varying intensity and the floodway boundaries. This information is presented on a Flood Insurance Rate Map and Flood Boundary and Floodway Map. The community adopts and enforces regulatory standards based on these maps. Currently, the City's Comprehensive Plan and Land Development Code support the FEMA program.

The City's stormwater collection systems were designed to collect and convey runoff for up to the 10-year return, 24-hour storm event. This is the amount of precipitation that occurs in a 24-hour storm event that has a 10 percent chance of occurrence in any given year.

The Corvallis area open drainageways, including streams and rivers, have been modified extensively by human activities over the last 150 years. Historical descriptions of the Corvallis landscape in the *1850s Federal Land Office Original Survey Notes* and historical aerial photos of the Corvallis watersheds from the 1930s demonstrate that significant modifications and relocation of the natural watercourse system have occurred. Most channel modifications (channel relocation, piping intermittent water-courses, and floodplain and adjacent wetland filling) for many of the last 40 years were made to accommodate urban development and agricultural practices, and worked against accommodating and managing larger flood events.

The total peak runoff flow that results from a storm event is directly related to (1) the soil's capacity to infiltrate water (soil saturation will affect this); (2) the elevation of ground water relative to the surface elevation; (3) the amount of impervious area (roofs, pavement); and (4) the amount of land-scape storage capacity, including basin-wide vegetative cover, channel-floodplain connections, and detention pocket areas such as wetlands, depressions, and swales. Typical urban development results in an increase in impervious area that also increases the peak flow from a given storm event. Imper-vious areas on steeper terrain result in more rapid runoff and greater peak flow than impervious areas on flatter terrain.

The City currently requires new private developments to use detention to keep development runoff equivalent to pre-development levels for up to the 10-year storm event. Infrastructure designed to manage water quantity can be achieved at different scales, ranging from large detention basins that serve entire developments to single-residential-lot methods.

Urban-related modifications to the peak runoff that enters area streams and rivers can have an ad-verse effect on the health of the receiving stream. Increased peak flows or frequency of peak flows can increase bank erosion, sediment transport, and downstream flood potential. Detention of runoff is an important tool to minimize the negative effects of peak flows from urban areas. However, there are areas within the lower reaches of the Corvallis area watersheds where improperly designed detention can actually accentuate downstream peak flows and flooding. Discharge strategies are therefore important in controlling effects on streams.

5.4.2.3 Citizen Input

Public input on water quantity management was provided through public meetings held by the SWPC, a random telephone survey of residents, and stakeholder interviews. Based on the telephone survey of 366 residents, a large number have first-hand experience with flooding. (See Appendix A for detailed survey results.) Over one-third of survey participants (37 percent) say they are affected by flooding, and for most of these it has become a routine occurrence. Over three-quarters (78 per-cent) reported that they are affected by one or more flood events during wet years. Twenty-two percent of respondents who have experienced flooding report damage to their homes, basements, or garages.

During the public workshops conducted by the SWPC, participants were asked to rate their support for water quantity alternatives. Attendees were supportive of all alternatives that addressed water quantity issues. Participants supported alternatives to:

- Develop public infrastructure to provide for Best Management Practices for stormwater quantity,
- Identify and acquire significant areas for natural detention,
- Protect upland vegetation to maintain stormwater function, and
- Develop guidelines to reduce impervious area for parking.

5.4.2.4 Strategies to Address Issues

Basin characteristics have a significant effect on water storage and on the timing and amount of runoff that enters the streams. Most important is the amount of rainfall, impervious area, vegetation, the rate of conversion of groundwater to surface flows, and runoff that exists in the watershed. Drainages that support proper stream functions typically require a minimum amount of water during specific times of the year. This amount of water is called the base flow, which is the water necessary to support healthy stream functions. Although base flows and groundwater recharge are critical elements of stream functions, saturated soils associated with building foundations can create structural challenges for developers. Engineering practices encourage the removal of groundwater beneath buildings and roads in order to provide a stable base. Compaction of soils and de-watering methods such as foundation drains discourage groundwater recharge. To address these issues, the City should encourage a range of design options that meet the detention and groundwater recharge objectives.

Existing policies and new policies are intended to reduce the effect of urban-influenced peak runoff and reduce the potential for urban-related downstream flooding. In response to the desires of the community, and as required by federal and State regulations, the SWMP provides program and policy recommendations to protect and improve stormwater quantity. In addition, recommendations are identified for activities that require further follow-up actions before implementation.

5.4.2.5 Goals

1. Maintain and accommodate natural hydrological processes, from base to peak flows.
2. Encourage percolation of rainfall into the ground.
3. Increase vegetative cover to retain and slow stormwater release.
4. Protect downstream properties from urban flooding.
5. Minimize urban-related erosion.

5.4.2.6 Existing Policies

1. To minimize the negative impacts of development, stormwater runoff after development should be managed to produce no significantly greater peak flow rates than prior to development, unless more appropriate provisions are identified in adopted comprehensive stormwater management plans (Comprehensive Plan Policy 4.10.5).

5.4.2.7 New Policies

QN-1 Through engineering analysis, the City shall establish stormwater detention and release standards for new development and redevelopment that preserve or restore the properly functioning conditions of the receiving waters.

QN-2 The City shall develop guidelines and evaluate the need for public infrastructure that provides for temporary detention in areas primarily dedicated to other uses, such as parks and open space, parking, and streets.

QN-3 The City shall develop standards for detention facilities. These facilities shall be located outside of stream channels unless it can be demonstrated that the properly functioning condition of the streams is maintained.

QN-4 The City shall consider the amount of impervious surface when evaluating detention requirements and develop a policy to encourage groundwater recharge opportunities.

QN-5 The City shall consider incorporating detention capacity when replacing or retrofitting the storm drainage system.

QN-6 The City shall consider acquisition of land and easements for future detention facilities.

QN-7 The City shall require the use of appropriate detention to control peak flows and reduce the potential for downstream erosion, flooding, and impairment of natural stream functions.

QN-8 To reduce peak runoff from impervious areas and maintain pre-development flow regimes, the City shall work to adopt standards such as the following:

a. Minimize the proportion of each development site allocated to surface parking and circulation.
b. Minimize the average dimensions of parking stalls.
c. Use pervious materials and alternative designs where applicable, such as infiltration systems.
d. Modify setback requirements to reduce the lengths of driveways.
e. Promote the use of shared driveways to reduce impervious surfaces in residential development.
f. Promote disconnection of roof downspouts to reduce runoff into a piped collection system or the street and encourage storage for reuse.
g. Retain a larger percentage of vegetated area within all types of development to increase rainfall interception.
h. Pursue the use of retention and infiltration facilities where the soils are suitable to control runoff volume, peak flow, and to promote dry-season base flows in streams.
i. Develop subsurface storage as well as surface detention facilities.
j. Evaluate additional restrictions on cuts in hillsides, especially in areas with near-surface groundwater.

QN-9 The City shall modify standards for managing urban runoff to allow for innovative building/landscape designs if it can be demonstrated that the resulting performance is comparable to existing building standards.

QN-10 The City shall encourage practices that enhance groundwater recharge to maintain or increase stream flow during dry periods.

QN-11 The City shall differentiate between natural flooding and urban-created flooding regimes and allow for natural flooding to occur while minimizing urban-created flooding (see FP-1).

QN-12 The City shall develop water quantity maintenance practices that protect, enhance, and restore the vegetative canopy along drainageways.

QN-13 The City shall use maintenance policies that enhance the natural detention capacity and upstream storage capacity of urban streams, such as retaining vegetation and wood, and allowing beaver dams to remain instream.

QN-14 The City shall provide incentives to developers for incorporating existing vegetation and open spaces into permanent stormwater facilities.

QN-15 The City shall develop standards to manage surface flows on developed sites to increase the time it takes for the water to reach the stream, where applicable.

QN-16 The City shall incorporate detention and water quality features into public street and municipal parking lot rehabilitation projects.

QN-17 To manage stormwater drainage and provide direction for developing standards, the City shall establish parameters and/or objectives for allowing new development to use vegetated swales or open channels.

QN-18 The City shall encourage parking lots to be constructed of stable pervious surfaces that do not degrade groundwater quality.

5.4.2.8 Suggested Follow-Up Actions

1. Recognize that the best efforts to mimic natural peak flood volumes and frequencies will probably not entirely maintain pre-development flooding regimes. Therefore, the City should design appropriate stormwater infrastructure, such as stream corridor widths, to accommodate those changes, including destabilized and widening channels, changes in the erosion and deposition patterns, etc.
2. The City shall identify steep terrain and consider implementing development standards for reducing impervious surfaces in these areas.
3. The City shall identify the runoff from impervious upland areas that is necessary to protect hydrological and habitat functions of areas downstream and consider development standards that maintain appropriate flows.

5.4.3 Uplands Natural Resource and Wetlands Management

5.4.3.1 Background

Upland natural resources and wetlands are an integral component of the stormwater functions within the overall watershed. Upland natural resources are the natural features and areas outside of the stream corridor and the 100-year floodplain that influence stormwater function and management. They include uplands, wetlands, vegetation, swales, and groundwater zones. Natural and human activities in these areas have a significant influence on stormwater, including the downstream channel and riparian areas. The Division of State Lands and the Army Corps of Engineers are responsible for the review and enforcement of the laws that govern wetlands in Oregon. In the landscape, wetlands provide water filtration and storage, and they support a unique habitat for aquatic and terrestrial creatures.

5.4.3.2 Issues

Land-disturbing activities in upland and wetland areas affect the natural storage and flow of stormwater, including both surface and subsurface flows. Development alters the natural process of stormwater infiltration into the ground and the recharge of the water table. The reduced quantity of infiltrated water can affect water supply to streams and wetlands, particularly to base stream flows during summer low-flow periods.

Vegetative management in upland and wetland areas influences water quantity and quality. Vegetation, including shrubs and trees, intercepts and stores precipitation until it is evaporated, while ground cover reduces soil erosion and slows overland flow. Improperly designed or sited urban development, poor construction practices, and forest or agricultural practices can alter hydrologic processes, resulting in increased flows, erosion, instream sedimentation, water quality degradation, and habitat loss.

Disturbances to wetlands and natural swales also influence water quantity and quality. Changes to surface flows, including an increase or a decrease in water volumes, can alter the form and ecological functions of natural features.

Existing local regulations governing upland natural resource and wetland management are in City and County codes and policies. The NPDES Phase II Stormwater Regulations and the ESA requirements also influence a number of activities within this category, as do the State and federal cut and fill programs. The Division of State Lands and Army Corps of Engineers currently enforce wetland regulations in the City and County. Citizens in the community have expressed concern that the Division of State Lands has not consistently implemented State and federal wetland regulations, and feel that strengthening these regulations through local policy might help to promote and encourage their more effective implementation. See Chapter 3 for more details on these regulations.

5.4.3.3 Citizen Input

Public input on upland natural resources and wetland management was provided through public meetings held by the SWPC, a random telephone survey of residents, and stakeholder interviews. Respondents to the telephone survey stated that protection of wetlands is an important issue. (See Appendix A for detailed survey results.) Eighty-eight percent rated protection of wetlands as "important" or "very important." Stakeholders who were interviewed also rated protection of wetlands as an important value. This was one of the key issues included as part of the "community livability" value expressed by those interviewed.

5.4.3.4 Strategies to Address Issues

Management of upland natural resources and wetlands in urban areas can protect or improve the stormwater-related functioning of these areas and can protect the health of the downstream systems.

In particular, this includes upland wetlands and natural swales, vegetation, and groundwater. These features provide for surface and subsurface runoff storage and transport, water quality protection, and natural habitat connectivity. Maximizing the tree canopy in upland areas reduces the down-stream effect of rainfall runoff by providing interception of rainfall.

In response to community values, and as required by federal and State regulations, the SWMP provides programs and policy recommendations for the upland areas to protect and improve stormwater quality and quantity. Also included are recommendations for follow-up actions.

5.4.3.5 Goals

1. Protect and enhance upland natural resources in order to maintain and re-establish hydrological functions and improve water quality.
2. Preserve and enhance biological functions of existing wetlands.
3. Maintain and accommodate natural hydrological processes.

5.4.3.6 Existing Policies

1. Consistent with State and federal policy, the City adopts the goal of no-net-loss of significant wetlands in terms of both acreage and function. The City shall comply with at least the minimum protection requirements of applicable State and federal wetland laws as interpreted by the State and federal agencies charged with enforcing these laws (Comprehensive Plan Policy 4.11.1).
2. Wetlands within the Urban Growth Boundary shall be identified and inventoried by the City or through the development process (federal regulation implemented through the DSL).

5.4.3.7 New Policies

UP-1 The City shall ensure that operation and maintenance practices protect, enhance, and restore upland natural areas and their functions and processes.

UP-2 The City shall identify upland natural areas and natural swales within the Corvallis Urban Growth Boundary (UGB) that provide important hydrological and habitat functions.

UP-3 The City shall develop stewardship guidelines that protect natural stormwater functions and processes associated with wetlands, natural swales, and vegetation.

UP-4 The City shall encourage the Division of State Lands to fully implement and enforce wetland protection goals and regulations within the City and the UGB to maintain hydrological and natural resource functions.

UP-5 The City shall develop and implement incentives for developers and property owners to protect, enhance, and re-establish wetlands, natural swales, vegetation, and groundwater for stormwater functions.

UP-6 The City shall explore opportunities to acquire lands to preserve stormwater functions through outright purchase, conservation easements, and partnerships.

UP-7 The City shall encourage wetland mitigation to occur in the same basin.

UP-8 Wetland mitigation should not compromise the existing stormwater functions of the land being used for the mitigation.

UP-9 New development and redevelopment shall not significantly impair the quantity and quality of water reaching wetlands.

UP-10 The City shall place a high level of significance on wetlands that are adjacent to streams.

UP-11 The City shall continue to inventory significant habitat and natural resource areas.

UP-12 The City shall continue to maximize preservation and restoration of existing upland natural resource areas and wetlands by use of development standards in the Land Development Code.

5.4.3.7 Suggested Follow-Up Actions

1. The City shall consider exceeding existing state and federal requirements for wetland protection.

5.4.4 Cross-Jurisdictional Basin Stormwater Management

5.4.4.1 Background

Most of the City's stream basins extend beyond existing City limits and the Urban Growth Boundary (UGB). In addition, all of the streams passing through the City originate within Benton County, outside the City limits. Some of the streams leave the City and pass back into the County before joining the Willamette River. To achieve many of the objectives presented in the SWMP, coordination is required between the City and Benton County. The City has an agreement with Benton County known as the Corvallis Urban Fringe Management Agreement (CUFMA), which outlines jurisdictional responsibilities within the urban fringe area (outside the City limits and within the UGB).

5.4.4.2 Issues

The flow, water quality, and vitality of the streams are influenced by activities conducted within the County, since the headwaters for many of the streams and wetlands lie outside the City. In particular, the City and Benton County should revise the plan for managing development within the urban fringe to incorporate the objectives of the SWMP.

5.4.4.3 Citizen Input

Public input concerning cross-jurisdictional basin stormwater management was provided through public meetings held by the SWPC. (See Appendix A for detailed public meeting results.) Many citizens recognized the need for coordination between government agencies to meet stormwater management objectives. Citizens, including those who live along watercourses downstream of Corvallis, also expressed concerns regarding water quality, water quantity, and stream health downstream of the UGB. A strong preference was shown for development of City and County agreements for stormwater management in the urban fringe. Citizen input also supported using a watershed-wide outreach approach to increase awareness regarding stormwater issues.

5.4.4.4 Strategies to Address Issues

A coordinated watershed approach to address stormwater management issues will include cooperative participation of the City and surrounding jurisdictions. In response to the desires of the community, and as required by state and federal regulations, the SWMP provides program recommendations to protect and improve stormwater quality. In addition, recommendations are suggested that require further follow-up actions before implementation.

5.4.4.5 Goals

1. Create and adopt a stormwater management program coordinated between the City and County.
2. Maximize citizen participation and understanding of cross-jurisdictional stormwater issues.
3. Identify stormwater objectives that are shared by the City, County, and public agencies.
4. Seek to manage watershed basins for stormwater functions, regardless of boundary lines.

5.4.4.6 Existing Policies

1. The City and County shall pursue the completion of mapping of floodplain and floodway (including the City's 0.2-foot floodway) within the UGB, or require this mapping through the development process (Comprehensive Plan Policy 4.8.4).
2. The City shall work with Benton County to adopt a cooperative program that implements standards for management of vegetation, such as removal of detrimental vegetation and preservation of beneficial vegetation along significant drainageways within the city limits and UGB (Comprehensive Plan Policy 4.10.10).

5.4.4.7 New Policies

CJ-1 The City shall work with other governing agencies to develop a basin-wide stormwater management approach with common goals and objectives.

CJ-2 The City shall develop cooperative agreements, watershed assessment tools, and mutually beneficial funding mechanisms with surrounding jurisdictions to protect streams, wetlands, and habitat throughout the entire watershed.

CJ-3 The City shall work with Benton County to update the Corvallis Urban Fringe Management Agreement to adequately address stormwater management issues. Surrounding counties may also be part of the basin-wide management strategy.

CJ-4 The City shall work with Benton County to encourage public participation and information outreach activities for all citizens within the watershed to further the objectives of the SWMP.

5.4.4.8 Suggested Follow-Up Actions

1. The City and County shall identify watershed protection and restoration opportunities that involve multiple agency and/or property owner partnerships.

5.4.5 Floodplain Management

5.4.5.1 Background

Flooding is a natural stream and river process that occurred before urbanization altered the landscape and drainage patterns. Floodplains accommodate and manage flows at times when water volume exceeds stream or river watercourse channel capacity. The City's Comprehensive Plan includes floodplains as a significant natural feature, and recommends that significant natural features be preserved or have their losses mitigated and/or reclaimed.

As urban areas expand, flooding typically occurs more frequently and with greater consequences. The floodplain must accommodate these hydrological modifications. The current City Land Development Code allows development within a portion of the floodplain, called the floodway fringe. The National Flood Insurance Program (NFIP) guidelines allow construction of new occupiable buildings in the floodway fringe provided they are elevated 1 foot above the base flood level. The guidelines also allow fill and/or flood proofing, depending on the type of structure. However, NFIP objectives do not factor in erosion and sedimentation, hydraulic energy modifications, habitat implications, and possible citizen isolation from services that can be associated with floodplain development. The February 2001 Draft Oregon State Goal 7 (Natural Hazards) suggests that local governments adopt floodplain measures that exceed the NFIP, including limiting placement of fill in the floodplain.

The City's Land Development Code implements NFIP and FEMA regulations by defining two flood zones:

> **Floodway** - Channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than 0.2 feet.
>
> **Floodway Fringe** - Portion of the 100-year floodplain outside of the floodway. This area may be developed under current policies.

5.4.5.2 Issues

Floodplains play a significant role within stream and river basins. Floodplains provide additional storage and transport capacity during larger storm events, reduce instream velocities and bank erosion, collect sediment, provide refuge and feeding areas for fish during floods, and increase the recharge of groundwater. The public is more commonly aware of the negative aspects of floodplain flooding, including property damage, effects on business and transportation, and health and safety risks. The City desires to implement a floodplain management strategy that will avoid placing development at flood risk, lessen land-use conflicts between floodplain hydrological function and urban development, protect floodplain hydrological function, and reduce the threat of urban-created flood damage to private property while maintaining many of the hydrological and other benefits associated with natural flooding. The placing of public infrastructure in or through a floodplain often encourages development within the floodplain. SWMP policies to address floodplain management are focused on preventing additional urban-created flooding while allowing for natural flooding.

Small stream systems are affected to a greater degree by local actions (floodplain modifications) than are the Marys and Willamette Rivers. However, fill in any floodplain can potentially create some risk of affecting adjacent and downstream properties.

For communities that wish to qualify for flood insurance, NFIP regulations require their local governments to implement measures to reduce the potential of property damage due to flooding. The federal government has also developed regulations to implement measures to protect and restore the viability of endangered species, to protect water quality, and to protect wetlands and waters of the State from the effects of dredging and filling. Each of these regulations will influence, at a minimum, how the City manages floodplains. For a discussion on current floodplain regulations, endangered species requirements, and NPDES Phase II Stormwater Regulations, see Section 5.4.2 or Chapter 3.

5.4.5.3 Citizen Input

Public input on floodplain management was received through a random telephone survey of residents and through public meetings held by the SWPC. (See Appendix A for detailed survey and public meeting results.)

In the telephone survey, many residents noted that they have had some experience with flooding, but most have not experienced property damage. A majority (84 percent) recognizes the importance of controlling development in floodplains. Recent citizen flooding experiences included not only localized floodplain inundation, but also flooded streets and other areas when surcharged stormwater pipes were not able to dispose of water to the receiving water bodies. Citizens also requested City action after residential yards in the floodplain were inundated during recent storm events.

During the public meetings, a number of citizens noted that it is not possible to eliminate flooding from the landscape. Many were concerned that averting flooding in one part of the watershed increases flooding in other areas. They also noted that many types of urban development in the floodplain could directly conflict with a primary function of floodplains: to accommodate and manage stormwater. The public also raised the issue of the cost to current landowners of restricting development in the floodplain. Some noted that the community should share these costs.

The SWPC also reviewed a range of floodplain development alternatives with the attendees at the public meetings. Feedback received from the workshops shows strong support for more restrictive standards for floodplain development. The following alternatives were presented to the participants:

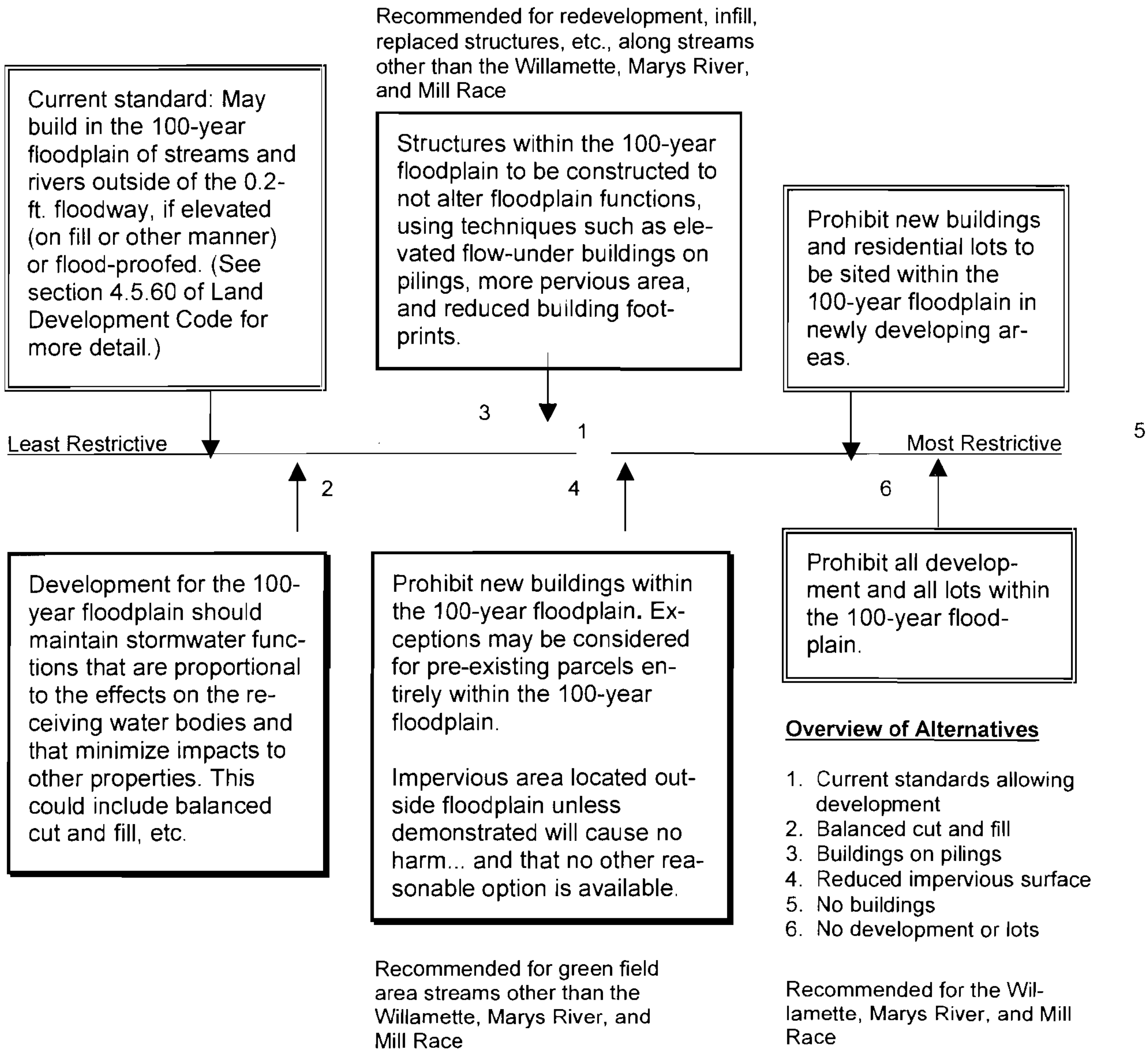
> **Alternative A** - Keep existing development standards. Development is allowed in the 100-year floodplain outside of the floodway, if elevated (on fill or without restricting flow), or flood-proofed.
>
> **Alternative B** - No net fill in the 100-year floodplain outside of the floodway. Allows development, but filling must be offset with excavation at the site to maintain flood storage capacity.
>
> **Alternative C** - Allow construction in the 100-year floodplain outside of the floodway, but structures must be elevated to not restrict flow, i.e., without fill or other water-displacing design.

Alternative D - No structural development within the 100-year floodplain. Use density transfer to offset floodplain development constraints for residential areas.

Thirty participants rated these alternatives and indicated strong support for the more restrictive alternatives (B, C, and D).

Figure 5-2 shows the range of development alternatives that the SWPC considered, along with highlighting some of the recommended policies.

Figure 5-2. Development Alternatives



5.4.5.4 Strategies to Address Issues

Developing accurate mapping of the floodways and 100-year floodplains in the UGB will help determine which areas are at risk of flooding. This data will provide decision makers with a clear understanding of the flood potential and the threat to existing structures.

In response to the desires of the community, and as required by State and federal regulations, the SWMP provides policy recommendations to protect and improve the floodplain function and processes, including both the 100-year floodway and floodway fringe. In addition, recommendations are suggested that require further follow-up actions before implementation.

5.4.5.5 Goals

1. Manage the 100-year floodplain for floodwater storage and transport.
2. Discourage activities in the 100-year floodplain that jeopardize floodplain functions.
3. Protect and enhance water quality and habitat by maintaining natural processes and functions.
4. Restore natural flooding capacity along urbanized streams.

5.4.5.6 Existing Policies

1. The City shall conduct further studies on methods to protect natural resources from the negative effects of development, such as transfer of development rights, Open Space - Conservation districts, or other useful measures (Comprehensive Plan Policy 4.5.5).
2. Development shall be prohibited within the floodway, except for bridges, public utilities, and seasonal and other temporary water-related uses that do not significantly alter the patterns of floodwater flows (Comprehensive Plan Policy 4.8.3).
3. Significant natural features within the UGB shall be identified and inventoried by the City or through the development process. These shall include:
   a. Seasonal and perennial streams and other natural drainageways, wetlands, and floodplains;
   b. Lands abutting the Willamette and Marys Rivers;
   c. Land with significant native vegetation as defined in the *Oregon Natural Heritage Plan (1998)*, which may include certain woodlands, grasslands, wetlands, riparian vegetation, and plant species;
   d. Ecologically and scientifically significant natural areas;
   e. Significant hillsides;
   f. Outstanding scenic views and sites; and
   g. Lands that provide community identity and act as gateways and buffers (Comprehensive Plan Policy 4.2.1).
4. Natural features and areas determined to be significant shall be preserved, or have their losses mitigated and/or reclaimed. The City may use conditions placed upon development of such lands, private nonprofit efforts, and City, State, and federal government programs to achieve this objective (Comprehensive Plan Policy 4.2.2).
5. The City and County shall pursue the completion of mapping of floodplains and floodway (including the City's 0.2-foot floodway) within the UGB, or require this mapping through the development process (Comprehensive Plan Policy 4.8.4).

5.4.5.7 New Policies

FP-1 The City shall acknowledge and accommodate natural flooding within the floodplain, and avoid or minimize urban-created flooding patterns.

FP-2 Development of new buildings on undeveloped lands (where such development does not fall within the definition of infill contained in Article 50 of the Corvallis Comprehensive Plan) shall be prohibited in the 100-year floodplain of Corvallis streams, with the exception of the Willamette River, the Marys River, and the Mill Race. If pre-existing parcels are entirely within the 100-year floodplain or if this policy renders an otherwise buildable parcel unbuildable, exceptions may be considered to allow limited development.

FP-3 Streets, alleys, driveways, and parking lots on undeveloped lands, with the exception of the Willamette River, the Marys River, and the Mill Race, should be located outside the 100-year floodplain and wetlands unless it can be demonstrated that they are constructed in a manner that does not restrict or otherwise alter proper floodplain functions, will cause no harm to the properly functioning condition of the stream, and that no other reasonable option is available.

FP-4 Infill and redevelopment in the 100-year floodplain of Corvallis streams, with the exception of the Willamette River, the Marys River, and the Mill Race, shall maintain or improve stormwater functions and floodplain functions existing prior to the proposed infill or redevelopment, using techniques such as flow-through designs, more pervious surface area, and reduced building footprints. Development standards shall be created to allow additions to existing structures consistent with those structures' design, provided the additions fall below the threshold of "substantial improvement" contained in the Land Development Code and are constructed consistent with FEMA standards.

FP-5 Area-specific development standards for the 100-year floodplain of the Marys River, the Willamette River, and the Mill Race shall be instituted to maintain stormwater functions, be proportional to the impact of the development on the receiving water bodies, and minimize impacts to other properties.

FP-6 The City shall develop a program to acquire land and easements that become available over time within the 100-year floodplain that are cost effective and provide opportunities that best remediate existing, or prevent future, flooding loss or damage.

FP-7 The City shall work to protect hydrological processes associated with the 100-year floodplain to support self-sustaining levels of native fish, aquatic species, and wildlife populations.

FP-8 New City infrastructure, including streets and sanitary sewers, should be located outside the 100-year floodplain and wetlands unless it can be demonstrated that they will cause no harm to the properly functioning condition of the stream and that no other reasonable option is available.

FP-9 The City shall develop and implement incentives for floodplain protection, enhancement, and restoration as part of the development process.

FP-10 The City shall allow for a variety of low-impact uses on publicly and privately owned floodplain lands provided it can be demonstrated that they do not harm floodplain functions.

FP-11 The City shall work to accommodate housing and other development opportunities that are displaced by floodplain protection measures to ensure a compact development pattern.

5.4.5.8 Suggested Follow-Up Actions

1. The City shall investigate the feasibility of constructing bridges to span the 100-year floodplain or a portion of the 100-year floodplain of permanent stream corridors or otherwise maintain connections in the floodplain (such as multiple culverts). The investigation should consider different stream-crossing standards for stream floodplains and the Willamette and Marys Rivers' floodplain and backwater areas.

5.4.6 Stream System Management

5.4.6.1 Background

Stream systems in the Corvallis area include intermittent streams and stream reaches, perennial streams, and major rivers. Some of these streams and their watersheds are entirely within the Urban Growth Boundary (UGB), while others extend beyond the UGB into agricultural and forest resource lands.

For the purposes of the SWMP, a stream system is defined to include the channel, banks, and a corridor of land along the channel. However, this SWMP recognizes that a more complete description of a stream system would also include headwater swales, the floodplain, and streamside wetlands. Swales, floodplains, and wetlands were primarily addressed in the earlier sections of this chapter.

A stream's form and behavior can vary significantly from reach to reach and between different systems. These different forms can require different management strategies. The following list gives some examples, illustrating the variety of stream forms in the Corvallis stormwater management area:

- Stream confluences into the Marys and Willamette Rivers, with associated low gradients, and floodplain backwaters.
- Narrow, channelized, and sometimes incised stream reaches with development near or at the top of the bank. This development is often placed on fill in the floodplain.
- Widely meandering streams with a primarily native vegetative canopy and understory.
- Ditched stream reaches through agricultural lands, with a narrow, immature vegetative canopy. These ditches are sometimes modified natural swales and wetland corridors.
- Heavily wooded stream corridors with forested watershed.
- Narrow, low-flow and intermittent streams that are landscaped, mowed, and used by property owners.

Management of stream systems for stormwater includes proper design of stream corridor infrastructure such as bridges, ongoing best management practices, and the designation of appropriate stream corridors. The stream corridors provide for stormwater functions that do not degrade or conflict with other ecological functions.

The City provides stream system management to reduce the flood potential resulting from blockages, to control erosion from urban runoff, to lower stream water temperature, and to improve water quality and habitat through vegetation management. Future management can also provide stormwater benefits including improvement and protection of water quality, allowance for natural channel movement and bank erosion, accommodation for natural flooding and protection of floodplains, protection of adjacent wetlands, protection of biological resources, reduction of drainageway maintenance costs, and minimization of conflicts with abutting land uses.

The City's Land Development Code requires a drainageway dedication or easement along stream corridors at the time of development. The dedication or easement is of variable width based on one of two formulas and determined by several factors:

- Channel width;
- Presence of streamside vegetation;
- Additional width if channel is incised; and
- Includes the entire 0.2-foot floodway, or the floodplain up to 50 feet, whichever is greater.

5.4.6.2 Issues

Stream system management has changed significantly in the last 40 years. Previous stream management efforts focused on quickly draining urban areas and maximizing available land for development. As a result, stream sections in older areas of Corvallis were altered (narrowed, straightened, and developed close to the top of the bank with little or no vegetative canopy). In many cases the floodplain and streamside wetlands were filled. Groundwater supplies that feed streams are gone or no longer reach the stream channel, while small feeder streams were piped. This type of stream channel and corridor does not allow for proper stormwater functions or support additional stream functions such as maintaining water quality, moderating flow peaks, and protecting fish and wildlife habitat.

Typically, the health of a stream system is inversely related to the degree of urbanization. To discourage this historical trend from continuing, special measures are required to protect the health and vitality of the streams. The regulations relating to stream system management are addressed through several state and federal programs, including the flood insurance program, Endangered Species Act, and the Clean Water Act. For more details about these regulations, see Chapter 3.

Additional issues were identified during the SWMP process, which include:

1. The historical use of stream corridors for above- and below-ground utilities paralleling the stream created conflicts with proper stream functions (sewer lines were most common);
2. The need to maintain the historical connectivity between streams and groundwater, and the supplies of groundwater to feed streams;

3. Possible use of an outer zone along stream corridors for enhanced stormwater functions, such as bioswales;
4. Concern over recent proposals to build instream structures for in-channel detention and past problems associated with existing structures;
5. Ownership of stream corridors (public versus private);
6. Allowing streams and stream corridors to provide for stormwater functions without degrading these systems;
7. Replacement of native or other suitable plants with grass up to the stream bank, and placement of outbuildings within dedicated drainageway corridors;
8. With objectives such as stream system enhancement and restoration, both short-term and long-term approaches will be needed to achieve goals. Protection is often less costly than restoration; and
9. Contamination of waterways (e.g., animal waste, trash) resulting from trails along stream corridors and disrupted natural drainage patterns from impervious surfaces.

5.4.6.3 Citizen Input

Public input into stream system management was provided through a random telephone survey, interviews, and public meetings held by the SWPC. (See Appendix A for detailed survey and public meeting results.) Almost half of the 366 residents surveyed live within six blocks of a stream. These residents expressed strong support for protection of stream habitat, with 94 percent stating that this is an "important" or "very important" value. Likewise, they indicated that loss of stream habitat is an important issue.

The results of the stakeholder interviews indicate strong support for stream system management. Included as an important value was public access to streams. Citizens expressed a preference for solutions that provide multiple benefits, such as improving habitat and providing recreational opportunities.

In the public workshops, the SWPC provided the following range of alternatives for setting stream corridor widths:

- Maintain existing standards of 7 feet to 77 feet on each side of the channel, depending on stream channel width (or floodway width, or riparian vegetation width, whichever is greatest).

- Vary stream corridor widths to address stream corridor functions, with a minimum 50-foot width on each side of the stream, and a maximum width of 100 feet on each side of the channel, (or floodway width, or riparian vegetation width, whichever is greatest).

- Vary stream corridor widths to address stream corridor functions, with a minimum 50-foot width on each side of the stream, and a maximum width of 150 feet on each side of the channel, (or floodway width, or riparian vegetation width, whichever is greatest).

- Vary stream corridor widths to address stream corridor functions, with a minimum 50-foot width on each side of the stream, and a maximum width of 200 feet on each side of the channel, (or floodway width, or riparian vegetation width, whichever is greatest).