West Linn Surface Water Management Plan

City of West Linn, Oregon

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In association with:
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Chapter 1

EXECUTIVE SUMMARY

This Surface Water Management Plan has been developed to: 1) evaluate the City's stormwater drainage system consisting of numerous drainage basins, treatment and detention facilities, open channel drainageways, and culverts, 2) provide recommendations for flood management, stream enhancement, and storm drainage water quality improvements, 3) to prepare a project listing with criteria to evaluate and prioritize the projects, 4) to provide the necessary data such that maintenance and repair procedures can be changed and project and operational budgeting can be accomplished to implement the plan, and 5) recommend areas for code changes to better manage storm drainage throughout the City. The previous plan was prepared by Woodward Clyde Consultants was adopted in 1996. In the intervening years significant changes have occurred in management of stormwater. The new plan also evaluates policies and regulations in place that govern the treatment and conveyance of stormwater and the streams and rivers into which the City's system drains and reviews them with regard to current federal, state, and local clean water and environmental regulations.

The City contracted with Pacific Water Resources (PWR) in January of 2002 by a contract consisting of two distinct phases. Subsequent to PWR's presentation of phase one results and draft deliverables, City staff was directed to accomplish phase two of the project in-house. PWR completed and compiled the phase one field summary investigation information, system modeling results, analysis, and project recommendations. In conjunction with a citizens' advisory committee appointed by the City Council, City staff reviewed and completed the document.

Anticipated flows are reduced, in some instances significantly, from the 1996 plan. This result can be attributed to better modeling techniques developed over the ten-year period, as well as the fact that the consultant utilized a completely different modeling program to evaluate the storm drainage basins. PWR prepared a proposed capital improvement project list based upon their analysis and it is contained within the management plan. In prioritization of these projects, the City utilized five criteria including capacity, fish passage, structural integrity, location, and maintenance. The project list will be used by the City to develop and recommend both short and long range project budgeting scenarios and the utility rates and system development charges (SDCs) to support the scenarios.

The plan reviewed existing City codes, the West Linn Sustainability Strategic Plan July 2006, and the West Linn Comprehensive Plan and found existing policies and practices are in compliance with these documents as well as federal, state, and local requirements for stormwater management and discharge limits. In the case of the City's Public Works Standards, the requirements are actually more stringent than required by outside government agencies. City staff is committed to monitoring changes to regulations and recommending code changes to remain in strict compliance. The citizens' advisory committee recommended that changes be made to City codes to move the City to a "greener" property development approach. The recommendations from that document relating to surface water management and properly considered by this plan are included in Chapter 9 – Recommendations. Those recommended changes not within the purvue of this plan are for Planning and Building to consider in future code updates and are not included in this plan.

Included in Chapter 7 is a table showing three possible funding scenarios for accomplishing the city-funded portion of the capital improvements list, Table 7.2.   Constructing the capital improvements and implementation of the recommendations in this document will depend on staff availability, budget, and City approval.

Chapter 2

INTRODUCTION

2.1 AUTHORIZATION

In January 2002, the City of West Linn contracted with Pacific Water Resources, Inc. (PWR) to develop a Surface Water Management Plan for Tualatin River and Willamette River drainages within the City's Urban Services Boundary (USB). The contract was broken into two phases. The first phase included the development of the basic information including field reconnaissance, both surface water quantity and quality modeling and analysis and natural resources evaluations. The second phase included the development of the plan including alternative analyses, public involvement and plan documentation.

The first phase or analysis phase was completed in October 2002. A presentation of the first phase results to the City Council occurred in November 2002 along with a request for direction from the Council on how to proceed with the second phase of the work. Based on the direction from Council received in May 2003, PWR was asked by the City to write a report that summarizes the completed first phase efforts and outlines the various options available to the City to achieve various stormwater planning objectives. The first six chapters of this document were designed to fulfill the City's request.

2.2 PLAN GOALS AND OBJECTIVES

The overall goals of the management plan are:

- To protect the public's safety, health, and property through flood control measures.
- To reduce the discharge of pollutants in stormwater runoff to the maximum extent practicable (MEP).
- To protect, restore and maintain the natural functions and values of the area's watersheds.

The regional goals of the management plan are:

- To coordinate program activities in a cooperative way with other affected communities and/or agencies.
- To encourage consistent development standards, erosion control standards and design criteria for stormwater control facilities.
- To cost share whenever possible in regional monitoring efforts and/or capital improvement projects.

The community objectives for stormwater management are as follows:

- Emphasize the use of non-structural methods, i.e., best management practices which focus on controlling runoff and pollution at the source.
- Protect the ecological integrity of rivers, streams, lakes, wetlands, and riparian corridors.

- Integrate both water quality and drainage control needs in the City's watersheds that also emphasize the use of natural systems.

- Coordination and/or consolidation of the City's resources to focus efforts on flood control and on the reduction of pollutants associated with stormwater runoff.

- Involve and educate the public in opportunities to improve surface water quality and aquatic habitat in riparian areas to minimize impacts of non-point source pollution.

- Implement funding mechanisms that equitably allocate costs to those that benefit from stormwater management.

- Ensure that expenditures of program elements are commensurate with their benefits.

2.3 PROBLEM STATEMENT

In an urban area, rain falls on impervious areas such as buildings, parking lots, playgrounds, streets, sidewalks and other areas where water cannot seep into the ground. This excess surface water runoff is collected and conveyed by a combination of storm drains, catchbasins, pipes, culverts, detention ponds and open drainage ditches, and groundwater until it is delivered to a natural stream or waterway.

At times of intense rainfall, the flow capacity of these drainage facilities and natural waterways can be exceeded and flooding can occur. During the management planning process it is imperative to identify the specific location and frequency of flooding throughout the major drainage systems. Then the flooding and its associated problems must be weighed against the cost of reducing the frequency of flooding through a specific capital improvement project.

Surface water runoff may transport sediments and their associated pollutants while en route to a natural stream or waterway. Pollutants of particular concern include phosphorus, nitrogen, oxygen demanding organic material, disease causing bacteria, oil and grease, heavy metals, and other toxics.

Human behavior also dramatically affects surface water quality. For example, the way people wash their cars, fertilize their lawns, dispose of liquid wastes and apply pesticides and herbicides, care for/pick up after their animals can significantly affect the water quality of streams, creeks, lakes or other waterways. In addition to increasing public education and awareness, the management planning process must identify methods to reduce pollutant washoff through enhanced maintenance practices, erosion control and changes in development techniques or standards. Also, the plan should identify specific locations where passive stormwater treatment facilities can be created or enhanced to develop pollutant reduction facilities (PRFs). Finally, all of these activities must be consolidated into a capital improvements program for funding and implementation.

All of these surface water management activities and improvements described above must be planned and coordinated in a manner that protects the physical and biological integrity of rivers, stream corridors and wetlands throughout the study area. Thus, a major emphasis of the plan is to use natural systems and, whenever possible, non-structural methods to control runoff volume and pollution at the source.

2.4 REGULATORY PROGRAMS

There are many stormwater related state and federal regulatory programs with which the surface water plan should be coordinated and which provide guidance on what specific actions are needed to help achieve the various program objectives.

Public Facility Planning

Chapter 660, Division 11 of the Oregon Administrative Rules (OAR) enforced by the Land Conservation and Development Commission (LCDC) require a public facilities plan for areas located within an urban growth boundary containing greater than 2,500 persons. This helps assure that urban development within the urban growth boundaries is guided and supported by the types and levels of facilities and services that are appropriate for the needs of the areas to be serviced. The Surface Water Management Plan presented herein satisfies the drainage related public facility plan requirements under Oregon Administrative Rules (OAR) 660-11-010.

Clean Water Act

Growing public awareness and concern for controlling water pollution in the late 1960's led to the federal enactment of the Water Pollution Control Act Amendments of 1972. As amended in 1977, this law has become commonly known as the Clean Water Act (CWA). The Act established the basic structure for regulating discharges of pollutants into the waters of the United States. It gave the Environmental Protection Agency (EPA) the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act also continued requirements to set water quality standards for all contaminants in surface waters. The Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. It also recognized the need for planning to address the critical problems posed by nonpoint source pollution.

EPA has authorized some states authority to administer the regulations of the CWA. In Oregon the Department of Environmental Quality has been authorized to oversee many of the federal environmental, health and safety regulations, including the Clean Water Act.

The CWA is composed of six titles each of which encompass sections outlining regulations for specific components of the act. For instance, Title IV section 402 provides language outlining the National Pollution Discharge Elimination System (NPDES) permit program.

NPDES Stormwater Program

Pursuant to Sections 402 and 405 of the federal Clean Water Act (CWA) Clackamas County is regulated by the National Pollutant Discharge Elimination System (NPDES) permit program. The City recognized the opportunity to be proactive in enhancing water quality and decided to participate in the NPDES program as a co-permittee under the Clackamas County permit. The permit is issued for a five-year period after which time the City must reapply. The initial permit was issued to Clackamas County and affiliated co-permittees in 1995, in 2000 the City of West Linn submitted a permit renewal application and in 2004 a new NPDES permit was issued to the City.

The NPDES program requires the City to reduce pollutants being discharged by the City's stormwater to the "maximum extent practicable" through the implementation of a storm water management plan (SWMP) which specifies best management practices (BMPs) that would be instituted to reduce pollutants in stormwater The City is currently in the process of developing a new SWMP that complies with the

2004 NPDES permit requirements. This Surface Water Management Plan must complement and coordinate closely with the City's new NPDES-driven Stormwater Management Plan.

TMDL Program

Section 303(d) of the CWA requires states to develop a list of waterbodies that do not meet water quality standards and thus require additional pollution controls. These waters are referred to as "water quality limited" and must be periodically identified in each state in a document commonly referred to as the "303(d) list". Water quality limited waterbodies require the development and implementation of a Total Maximum Daily Load (TMDL) for bringing a waterbody into compliance with water quality standards.

The Willamette River has been identified by DEQ as "water quality limited" based on elevated levels of 2, 3, 7, 8-TCDD in fish tissue and sediments. In addition, the Willamette River has been measured by DEQ with elevated levels of 307(a) pollutants (*i.e.*, PCB and phenol) near the Sellwood Bridge. Below the Sellwood Bridge, other parameters of concern measured by DEQ include heavy metals (cadmium, copper, lead, mercury and zinc) and organic toxics (PAHs, PCBs, chlordane, DDT, creosote, and phthalates). The development of specific TMDLs are currently underway.

The Tualatin River has also been identified by DEQ as "water quality limited". TMDLs have been developed for temperature, bacteria volatile solids, ammonia, and phosphorus.

A TMDL process determines the pollutants or stressors causing water quality impairments; identifies maximum permissible loading capacities for the waterbody for each relevant pollutant; and then, assigns pollutant load allocations to each identified and permittable source, including both point (wasteload) and non-point (load) sources in the watershed. Water quality management plans that identify and implement source controls and other BMPs need to be implemented to restore streams and rivers and eventually meet water quality standards. The City's 2004 NPDES permit incorporates the load allocations set forth in the Tualatin River TMDL and requires measures to be adopted and implemented to achieve pollution reduction targets that will result in TMDL compliance. The NPDES-driven Stormwater Management Plan (SWMP) and the Surface Water Management Plan combined should satisfy the requirements for a TMDL water quality management plan for the City of West Linn's portion of the Tualatin River drainage basin.

Endangered Species Act (ESA)

The Endangered Species Act (ESA) provides for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The National Oceanic Atmospheric Administration Marine Fisheries Service (NOAA Fisheries) and the U. S. Fish and Wildlife Service (USFWS) both have administrative authority and management responsibility for different species under the ESA. A species may be listed under the ESA as either *endangered*, "in danger of extinction throughout all or a significant portion of its range," or *threatened*, "likely to become endangered within the foreseeable future throughout all or a significant portion of its range."

Section 9 of the ESA prohibits the "take" of any threatened or endangered species. "Take" is defined as harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting, or attempting to engage in any such conduct. "Harm" is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.

Within the Portland metropolitan area steelhead trout, Chinook salmon, and Coho salmon are listed as threatened species under the ESA, and are under the administrative jurisdiction of NOAA Fisheries. All three of these species are located in both the Willamette River and the Tualatin River and therefore are within West Linn's jurisdiction.

For species listed as threatened, section 4(d) of the ESA requires NOAA Fisheries or USFWS to put "take" prohibitions in place, and approve programs for activities that contribute to conserving listed salmon and steelhead. These actions are termed "4(d) rules." If a municipality partakes in activities listed in the 4(d) rules, it can develop a program for approval by the jurisdictional agency (NOAA Fisheries or USFWS) to reduce liability under the ESA, or the municipality can implement activities to ensure no "take" results.

National Marine Fisheries Service (NMFS), which is now called NOAA Fisheries, developed 4(d) rules that pertain to Pacific Northwest salmon and steelhead ESA listings. Within the 4(d) rules there are several limits. One such limit that is directly applicable to West Linn's stormwater-related activities is the: Municipal, Residential, Commercial, and Industrial (MRCI) Development and Redevelopment limit. The MRCI limit contains twelve sub-parts, which outline considerations for development and redevelopment in protection of a listed species. The twelve subparts follow:

1. Avoid inappropriate areas (unstable slopes, wetlands, areas of high habitat value, and/or similarly constrained sites).
2. Avoid stormwater discharge that could impact water quality and quantity or influence the hydrograph of the watershed.
3. Require adequate riparian buffers around perennial and intermittent streams, lakes, or wetlands
4. Avoid stream crossings by roads whenever possible. When stream crossings are necessary, minimize impacts through choice of mode, sizing, and placement.
5. Protect the historic stream meander pattern and channel migration zones; avoid hardening of streambanks.
6. Protect wetlands and wetland functions.
7. Preserve the hydrologic capacity of any intermittent or permanent stream to pass peak flows.
8. Landscape with natives to reduce need for watering and application of herbicides, pesticides, and fertilizer.
9. Prevent erosion and sediment runoff during construction.
10. Assure that water supply demands for the new development 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 manner that prevents injury or death of salmonids.
11. Provide all necessary enforcement, funding, reporting, and implementation mechanisms.
12. The development complies with all other state and federal environmental or natural resource laws and permits.

This Surface Water Management Plan document directly addresses the first nine items of the twelve listed above.

Metro Urban Growth Functional Plan – Title 3

In November 1996, the Metro Council adopted a regional Urban Growth Functional Plan. It contains 11 "titles" or policies that relate to managing and shaping future growth in the Portland region. Local jurisdictions are required to comply with these requirements by adopting model ordinances or developing their own that are substantially similar and amending their comprehensive plans and development codes. Title 3 of the Urban Growth Functional Plan deals with protecting stream corridors, wetlands, and floodplain areas.

The original Title 3 contained a placeholder for addressing standards for protecting and restoring fish and wildlife habitat along streams and within wetland areas. However, after NOAA Fisheries listed trout and salmon as threatened under the ESA, Metro decided to proceed somewhat earlier than originally planned to develop these standards. The goal of the program is to develop standards that local jurisdictions can adopt that will comply with both the NOAA Fisheries 4(d) rules (see ESA discussion) as well as State Planning Goal No.5: Open Spaces, Scenic and Historic Areas, and Natural Resources (see Oregon Comprehensive Land Use Planning discussion). West Linn continues, through the West Linn Community Development Code Chapters 28–32, to develop natural resource protections and programs for streams, wetlands, and floodplains in accordance with Title 3 stipulations.

National Flood Insurance Program (NFIP)

The Federal Emergency Management Agency (FEMA) exercises regulatory control over development occurring in flood areas. While FEMA regulations are not specifically geared toward the issue of water quality, however, they certainly address the concern about flooding.

The National Flood Insurance Program (NFIP) is a federal program that allows property owners to purchase flood insurance protection. Participation in the NFIP is based on an agreement between local communities and the federal government. In exchange for the availability of flood insurance within the community, communities must implement measures to reduce future flood risks. These measures involve restrictions on the construction of habitable structures within the mapped floodplains and floodways. Owners and occupants of insurable flood prone properties may purchase NFIP flood insurance through licensed property insurance agents or brokers.

Most of the nation’s communities with serious flooding potential have joined the NFIP, though FEMA still encourages communities to consider more restrictive flood protection standards. More stringent requirements adopted at the state or local level would take precedence over requirements outlined in the NFIP.

As part of the NFIP, local FEMA administrators work with members from each participating community to establish a local Flood Insurance Rate Map. The map is intended to show areas within the 100-year flood boundary, also known as Special Flood Hazard Areas (SFHAs), which are subject to minimum floodplain management standards. A 100-year flood is a flood level that has a 1 percent chance of being equaled in any given year.

Minimum floodplain management standards in SFHAs have two purposes: 1) to prevent new development from increasing the flood threat, and 2) to protect buildings from future flood events. To ensure that appropriate construction materials and methods have been used, local permitting offices are required to obtain detailed documentation on construction techniques for all new development and substantial redevelopment.

FEMA may also designate a *floodway* in urban areas to avoid significantly increasing upstream flood elevations. A *floodway* is defined as the river channel and adjacent floodplain that must remain unobstructed in order to discharge the base flood without increasing flood levels by more than one foot. Under NFIP, communities must prohibit any development in the designated floodway that could cause an additional rise in the base flood elevation.

Oregon Comprehensive Land Use Planning

In addition to the public facilities planning discussed earlier in this chapter, the comprehensive plan provides the framework for protecting and enhancing water quality and the management of flood hazard areas. All water quality provisions in the land development code should be supported by the appropriate comprehensive plan goals and policies. Oregon Statewide Planning Goal 2: Land Use Planning, indicates that, "all land use plans shall include identification of issues and problems, inventories and other factual information for each applicable statewide planning goal, evaluation of alternative courses of action and ultimate policy choices…"

Due to the changing regulatory environment, acknowledged (i.e. approved by LCDC) local comprehensive plans may not adequately address water quality. New TMDL rules and ESA regulations are good reasons to review and update portions of the comprehensive plan. In the end, local jurisdictions will need to determine how to best address water quality and habitat protection in conjunction with state and federal agencies. A review of the comprehensive plan may reveal areas that can be strengthened, or where a community dialogue needs to occur about the proper method of protecting and enhancing water quality and protecting life and property from flooding.

The following is a summary of the Oregon Statewide Planning Goals that relate to various stormwater concerns.

Goal 5 – Natural Resources, Scenic and Historic Areas, and Open Spaces
Goal 5 has received much attention in the last few years. Administrative rules were adopted in August of 1996 that require local governments to inventory and evaluate Goal 5 resources, and develop land use programs that conserve and protect significant Goal 5 resources. The Goal 5 rules require that a local inventory and protection strategy be developed for three Goal 5 resources by completion of the jurisdiction's next periodic review. These resources are:

- riparian corridors, including water and riparian areas and fish habitats;
- wetlands;
- wildlife habitat

Goal 6 – Air, Water and Land Resources Quality
Unlike Goal 5, Goal 6 does not have administrative rules to set standards for meeting the goal. Instead, it relies entirely on other state and federal regulations for direction and implementation. However, for water quality purposes, Goal 6 has the potential for being the most important land use planning goal. The Goal requires that "all waste and process discharges from future development, when combined with such discharges from existing developments shall not threaten to violate, or violate applicable state or federal environmental quality statutes, rules and standards."

State definitions for wastewater and pollutants include pollutants carried by stormwater, and impacts on habitat that result from stormwater flows. Goal 6 requires jurisdictions to integrate compliance with federal and state water quality regulations with their comprehensive planning process.

Goal 7 – Areas Subject to Natural Disasters and Hazards
While Goal 7 does not point specifically towards the issue of water quality, it does deal with the concerns of flooding. This goal notes that comprehensive plans "should consider as a major determinant, the carrying capacity of the air, land and water resources…(and) should not exceed the carrying capacity of such resources." In protecting against floods and other natural disasters,

local governments may jointly address issues of water quality, such as limiting development within floodways and reducing impervious surfaces that increase runoff and flooding.

2.5 HEALTHY STREAMS

Achieving the goals set forth in the many regulatory programs outlined above will require a watershed perspective and the implementation of both surface water and stormwater management plans that promote healthy streams. Watersheds are distinct landforms that drain water from topographical divides to a network of streams and rivers that flow to the ocean. A watershed *collects* water from rainfall and snowmelt, *stores* water in various amounts and for various durations within the landscape, and *discharges* water as runoff when its storage capacity is exceeded. A watershed also provides *pathways* along which physical and chemical processes take place and *habitat* for the flora and fauna that promote the biological cycles of the system. Maintaining the integrity of these functions through natural ecological progression or succession is critical to the survival of a healthy watershed.

Ecologically healthy watersheds are maintained by active natural disturbance regimes (*e.g.*, fire, landslides, floods, channel migration, animal manipulation) and will respond and adjust to changing conditions. Natural disturbance regimes encourage considerable variability and diversity in the physical components of the system. These physical changes are reflected in the productivity and biodiversity of aquatic and upland species of plants and animals. At the heart of an ecologically healthy watershed is the vegetated riparian area (adjacent to the streams) and associated wetlands. The riparian area is shaped by channel geomorphology (channel form created by specific soil/water interactions), hydrologic pattern (water movement), its position in the watershed (high up near the headwaters vs. down in the lower reaches), and disturbance regimes. Riparian forests and wetlands also affect and are affected by habitat dynamics and water quality. Maintenance of these landscape features is of fundamental importance to the vitality of a watershed. A healthy watershed is critical for those that rely on its integrity for survival.

The values of a healthy watershed can also be viewed in human terms. Some individuals value clean water and wildlife in their back yards or along a greenway. Others need clean water for irrigation or production of a product. Many value the ability of the landscape to hold water and keep their homes from flooding. Whatever the reasons, humans desire and need healthy watersheds and streams.

In order to assess the quality of West Linn’s watersheds it is necessary to first understand the physical characteristics of the study area. Chapter 3 provides a background of natural physical attributes as well as the human imprint on West Linn.

Chapter 3

STUDY AREA CHARACTERISTICS

The regional setting and the physiographic features of the study area influence its physical characteristics. Knowledge of these elements is important to understand how they affect surface water management. These natural features also influence development that has occurred and will occur in the future. Solutions to manage surface water and control pollutants depend upon basic understanding of these factors and their interrelationships.

3.1 LOCATION

The City of West Linn is located in northwest Clackamas County, Oregon, approximately nine miles south of the City of Portland. The study area is approximately coincident with the urban services boundary of the City, except on its western edge where it includes unincorporated areas of Clackamas County, which drain into the City's stormwater system. The study area is bounded by the Willamette River on the east, the Tualatin River on the southwest, unincorporated Clackamas County on the west and City of Lake Oswego on the north. The size of the study area is approximately 5,236 acres (8.2 mi^2) (See Figure 3.1. All of the figures follow the text at the end of each chapter).

3.2 CLIMATE

The study area climate is described as a modified marine type that is characteristic of the weather patterns that dominate the Pacific Northwest region. Warm, moist air moving from the Pacific Ocean 60 miles west moderates the seasonal weather extremes. Summers tend to be warm and dry; winters are wet with extended periods of cloudiness. The annual average high temperature is 64 degrees; the average low is 54 degrees. Annual precipitation averages approximately 47.5 inches, the large majority (85 percent) of which occurs during the period from October through April and with over half of the annual precipitation occurring from November through February.

3.3 TOPOGRAPHY

The topography of the study area varies from relatively flat areas along the Willamette and Tualatin Rivers to rolling hills on the western part of the City. Ground elevations vary between 20 feet above mean sea level (ft MSL) along the rivers to 743 ft MSL near Suncrest Drive and Derby Street. The mean ground elevation in the City is 280 ft MSL.

Relatively flat areas (surface slope is less than 5 percent) represent approximately one quarter of the study area. Moderately steep to steep slopes (5 to 25 percent) are observed on approximately 65 percent and very steep slopes (greater than 25 percent) on 11 percent of the study area. Surface slope ranges are indicated in Table 3.1 and shown on Figure 3.2.

Table 3.1 Slope Ranges in the Study Area

Slope Range (%)	Percent of Total Area	Area (acres)
0-5	23.3	1,212
5-10	28.7	1,505
10-15	17.0	891
15-20	13.9	728
20-25	5.8	306
>25	11.3	594
Total	100.0	5,236

Source: Analysis of Metro's 2001 aerial topographic survey

3.4. LAND USE

Based on the City's zoning, the existing land use distribution within the study area is shown in Figure 3.3 and tabulated in Table 3.2. The majority of the study area is zoned R-10 which is low density with a minimum lot size of 10,000 ft^2. The total residential zoned area, including low, medium and high density, is approximately 67%. The county land is generally undeveloped area currently used for agriculture or larger home sites. The vacant land is 722 acres within the entire study area and is distributed throughout all categories of zoning. Most of the vacant lands are individual lots within the City that have not yet been developed to their land use designation but contain a residence. There are also vacant lots totaling about 225 acres with no structures on the property.

Table 3.2 Existing Land Use Distribution of the Study Area

Land Use Zone	Zone Definition	Area (acres)	Percent of Study Area
R-40	Low Density- Minimum 40,000 sf lot	3	0.1
R-20	Low Density- Minimum 20,000 sf lot	56	1.1
R-15	Low Density- Minimum 15,000 sf lot	158	3.0
R-10	Low Density- Minimum 10,000 sf lot	2,485	47.5
R-7	Low Density- Minimum 7,000 sf lot	240	4.6
R-5	Medium Density- Minimum 5,000 sf lot	183	3.5
R-4.5	Medium Density- Minimum 4,500 sf lot	150	2.9
R-3	Medium High Density- Minimum 3,000 sf lot	106	2.0
R-2.1	Medium High Density- Minimum 3,000 sf lot	125	2.4
NC, GC, OBC	Commercial	181	3.5
CI, GI	Industrial	194	3.7
CNTY	Unincorporated County Land	611	11.7
RDS	I-205 Right of Way	224	4.3
PKS/OS	Park, Open Space	520	9.9
	Total	5,236	100.0

The land use distribution for the future conditions within the study area was created from the City of West Linn Comprehensive Plan (adopted December 1983, amended July 2000, October 2003). The Comprehensive Plan is used to set development policy for the City. It outlines what type of development will occur within the city limits. Based on information produced in the Comprehensive Plan, Figure 3.4 and Table 3.3 were created. They show the type of development and the projected land area attributed to each category within the study area. In the hydrologic modeling described in Chapter 4, the unincorporated county land was assumed to be rural residential. The total residential land under future development conditions (excluding the unincorporated county land) is estimated to grow to approximately 80% of the study area.

Table 3.3 Future Land Use Distribution of the Study Area

Land Use Zone	Zone Definition	Area (acres)	Percent of Study Area
LOW	Low Density Residential	3,587	68.5
MED	Medium Density Residential	402	7.7
MEDHIGH	Medium-High Density Residential	200	3.8
IND	Industrial	193	3.7
COMM	Commercial	183	3.5
CNTY	Unincorporated County Land (Rural Residential)	417	8.0
PKS	Parks and Public Open Space	23	0.4
RDS	Roads (I-205)	231	4.4
	Total	5,236	100.0

Development in the West Linn area has been occurring for over 100 years. Based on the City's GIS information, Figure 3.5 shows the time period when properties in West Linn were developed. From the figure it is apparent the older structures within the study area are centered around the Willamette City area and other areas close to the river. The most recent development is found mostly on the tops of the bluffs above the river. Each age of development was constructed with different building standards and preferences, which can affect how stormwater is conveyed and treated for detention and water quality.

3.5. VEGETATION

The type of vegetation within an area can impact the amount of runoff generated from a storm. A dense forest will intercept significant precipitation before it reaches the ground, limiting its availability to become runoff. An area with very few trees and grass vegetation coverage allows more precipitation to reach the ground and perhaps become runoff. The vegetation coverage for the West Linn study area was taken from the Metro Regional Land Information System (RLIS). Table 3.4 lists the types of vegetation coverage that were found in the study area and Figure 3.6 illustrates the coverage. The 'Urban' vegetation designation refers to lawns and smaller trees that would be located in landscaped areas. The 'Urban' coverage generally coincides with the areas of residential zoning. The Agriculture and Clear Cut sites are both located in the unincorporated county portion of the study area.

Table 3.4 Vegetation Cover Type in the Study Area

Vegetation Cover Type	Description	Area (acres)	Percent of Total Area
A	Agriculture	99	1.9%
CC	Clear Cut	46	0.9
FC	Forest Closed Canopy	778	14.9
FO	Forest Open Canopy	222	4.2
FS	Forest Scattered Canopy	79	1.5
M	Meadow/Grassland	73	1.4
SC	Scrub/Shrub Closed Canopy	163	3.1
SO	Scrub/Shrub Open Canopy	72	1.4
SS	Scrub/Shrub Scattered Canopy	147	2.8
U	Urban	3,520	67.2
W	Water	37	0.7
	Total	5,236	100.0

3.6 SOILS

When precipitation reaches pervious ground it either becomes runoff or is infiltrated depending upon the infiltration rate of the underlying soils and amount of vegetation. A soils coverage of the West Linn study area was created for the GIS analysis. The base data was provided by the City of West Linn GIS branch. The basis of the information is taken from the Soil Conservation Service (SCS) Soil Survey of Clackamas County Area, Oregon (Nov. 1985). The soils map Figure 3.7**,** contains all soils found within the study area. Table 3.5 contains each soil type found in the soil map as well as the amount of area each soils type encompasses. Many soils have more than one classification under the same name, such as 23B, 23C, and 23D. The letter suffixes refer to the topographic slope the soils are located within. Table 3.5 also illustrates the slopes associated with each letter. The listed slope ranges are general ranges and may not hold true for all soils.

Key types of soils that relate to the watershed attributes (e.g. wetland areas) are hydric soils and highly permeable soils. Figures 3.7 and 3.8 illustrate these soil types within the study area.

Table 3.5 Soils in the Study Area*

SCS Soil Number	Soil Name	Area (acres)	Percent of Total Area	Soil Slope Classification
1A, 1B	Aloha Silt Loam	362.7	6.9	0-3%, 3-6%
3	Amity Silt Loam	35.9	0.7	0-3%
7B	Borges Silty Clay Loam	71.1	1.4	0-8%
11	Camas Gravelly Sandy Loam	9.4	0.2	0-3%
13B, 13C, 13D	Cascade Silt Loam	582.2	11.1	3-8%, 8-15%, 15-30%
16	Chehalis Silt Loam	41.1	0.8	0-3%
19	Cloquato Silt Loam	125.9	2.4	0-3%
23B, 23C, 23D	Cornelius Variant Silt Loam	954.7	18.2	3-8%, 8-15%, 15-30%
25	Cove Clay	63.5	1.2	0-2%
30C	Delena Silt Loam	75.0	1.4	3-12%
36B, 36C	Hardscrabble	29.4	0.6	2-7%, 7-20%
41	Huberly Silt Loam	13.7	0.3	0-3%
45C	Jory Silt Clay Loam	8.2	0.2	8-15%
48C, 48D	Kinton Silt Loam	139.8	2.7	8-15%, 15-30%
53C	Latourell Loam	25.7	0.5	8-15%
56	McBee Silty Clay Loam	18.1	0.3	0-3%
57	McBee Variant	8.7	0.2	0-3%
64B, 64C	Nekia Silty Clay Loam	175.3	3.3	2-8%, 8-15%
67	Newberg Fine Sandy Loam	98.1	1.9	0-3%
73	Riverwash	8.6	0.2	0-3%
78A, 78B, 78C, 78D	Saum Silt Loam	736.4	14.1	3-8%, 3-8%, 8-15%, 15-30%,
82	Urban Land	16.7	0.3	0-30%
84	Wapato Silty Clay Loam	7.4	0.1	0-3%
88A, 88B	Willamette Silt Loam	230.9	4.4	0-3%, 3-7%
89D	Witzel Very Stoney Silt Loam	452.2	8.6	3-40%
91B, 91C	Woodburn Silt Loam	590.9	11.3	3-8%, 8-15%
92F	Xerochrepts	301.4	5.8	20-60%
W	Water	52.9	1.0	0-3%
	Total	5,236	100.0	

*Information is from the Soil Conservation Services Soil Survey of Clackamas County Area, Oregon (November 1985)

3.7 WATERSHEDS

A watershed is an area that drains to a specific river, creek or waterway. The study area, as noted earlier, drains to either the Tualatin River or the Willamette River. A total of twenty-one (21) creeks and their associated watersheds were identified for hydrologic modeling throughout the West Linn study area. Figure 3.9 illustrates the name and location of these watersheds and stream corridors. The original stream delineations by the City did not include two additional streams that were identified for detailed hydrologic analysis. The two added streams are shown as Dollar Creek and Summerlinn Creek. The naming of these two watersheds and creeks is based on streets adjacent to the streams.

Turkey Creek which was identified by the City has not been included in the detailed modeling because the stream is almost entirely within the Mary S. Young Park and no major conveyance facilities are located along its reach. Several of the delineated and named streams are in fact tributaries to other delineated and named streams. Stevens Creek is one that was identified by the City. Since it is a very small upland tributary of Fritchie Creek, Stevens Creek is included in the Fritchie Creek watershed and is not shown separately as a major basin.

Within the study area there are areas in close proximity to the Tualatin and Willamette Rivers draining directly into these rivers. These areas were not included in the detailed hydrologic study area (see Chapter 4) because they a have limited infrastructure and/or the stormwater collection system is too small to warrant a detailed study. Peak runoff flow rates for these areas may be estimated based on a unit area average from the detailed study area results presented in Chapter 4.

3.8 STORMWATER COLLECTION SYSTEM

The existing stormwater collection system within the study area is made up of natural channels, ditches, and pipes. Recent development in the study area has included stormwater detention facilities such as ponds, and underground storage tanks. Water quality treatment facilities have also been included in the stormwater collection system. Most of the water quality facilities were constructed as part of the newer development and are predominantly swales and ponds.

Most of the main creeks are entirely open channel with culverts at road crossings. The piped collection systems that are constructed within developments convey the stormwater to the creeks. The older developed areas, those constructed prior to 1960s, collect stormwater in roadside ditches. These areas are generally located closer to the rivers and the ditches discharge flow directly to the creeks. A detailed analysis of most of the stormwater collection system will be presented in Chapter 4.

3.9 FLOODPLAIN

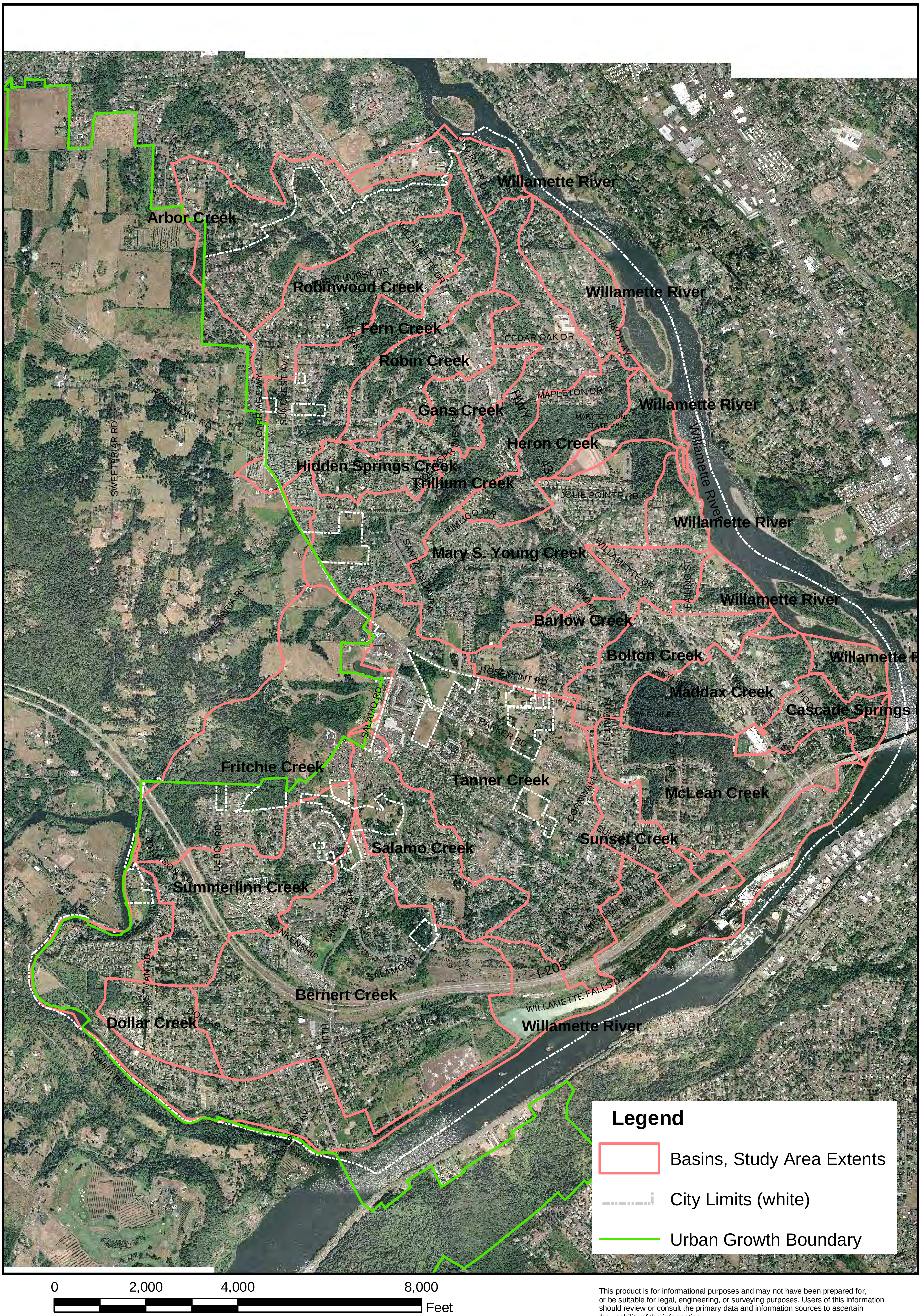
Flooding within the City is directly related to flooding on the Willamette and Tualatin Rivers. Historic records indicate that flooding occurs in winter and spring. The greatest floods on the Willamette and Tualatin Rivers have resulted when abnormally heavy or prolonged rainfall coincides with snowmelt and either frozen or nearly saturated ground conditions. The combination of these factors creates conditions that produce the maximum amount of runoff and the potential for widespread flooding.

The largest recent flood on the Willamette River occurred in February 1996. Its peak discharge at the Morrison St. Bridge in downtown Portland was estimated to be 420,000 cubic feet per second (cfs). The flood reached an elevation of 28.6 ft at this location, which was 0.2 ft below the published 100-year water surface elevation. The December 1964 flood at the same location (i.e. Morrison St. Bridge) reached 28.9 ft with an estimated peak discharge of 440,000 cfs.

The largest flood ever recorded on the Tualatin River also occurred in February 1996 with an observed flow of 26,400 cfs at the West Linn gauge near the river's mouth. The overflow from the Tualatin into the Oswego Canal during this historic event was measured at 5,100 cfs. A pending Flood Insurance Restudy of the Tualatin River has concluded that this historic event had a 1.2% annual chance of occurrence, which translates to an 84-year return interval flood.

The revised 100-year flood has an estimated flow at West Linn of 27,420 cfs with an estimated 6,180 cfs overflowing into Oswego Lake via Oswego Canal. This represents a 7 percent increase in the estimated 100-year flood peak discharge at West Linn, which will only increase the 100-year water surface elevations throughout West Linn by a few tenths of a foot over its existing published values.
Figure 3.10 shows the approximate extent of 100-year floodplain throughout the study area for both the Willamette and Tualatin Rivers published by FEMA. Current floodplain map panels can be obtained from FEMA's Flood Map Store at www.fema.gov.

Surface Water Management Plan 2006



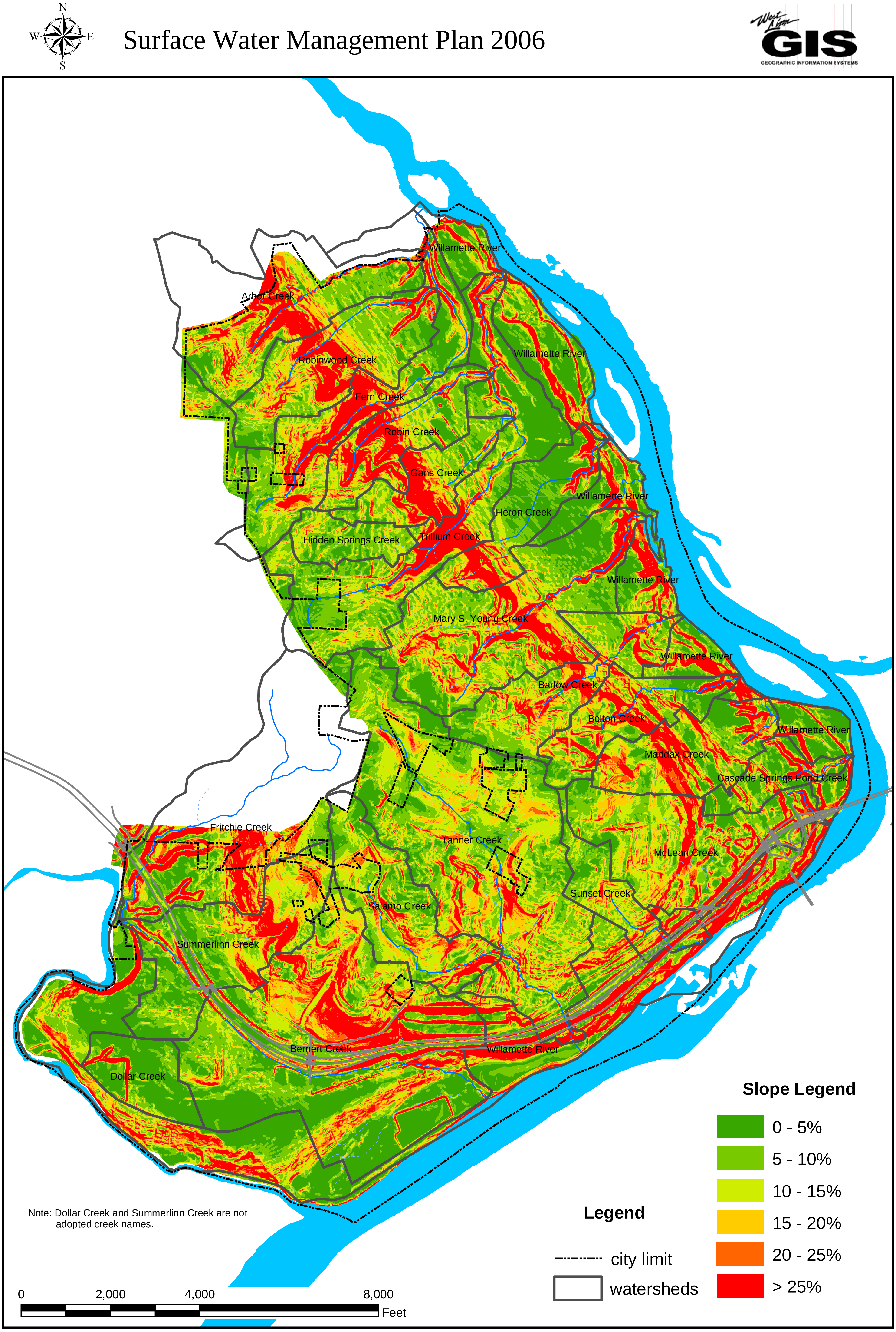
This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Figure 3.1 Study Area

Taxlot Base Source: Clackamas County GIS

storm_mp2004\fig21_studyarea.mxd | Lee | 9-14-06

Surface Water Management Plan 2006



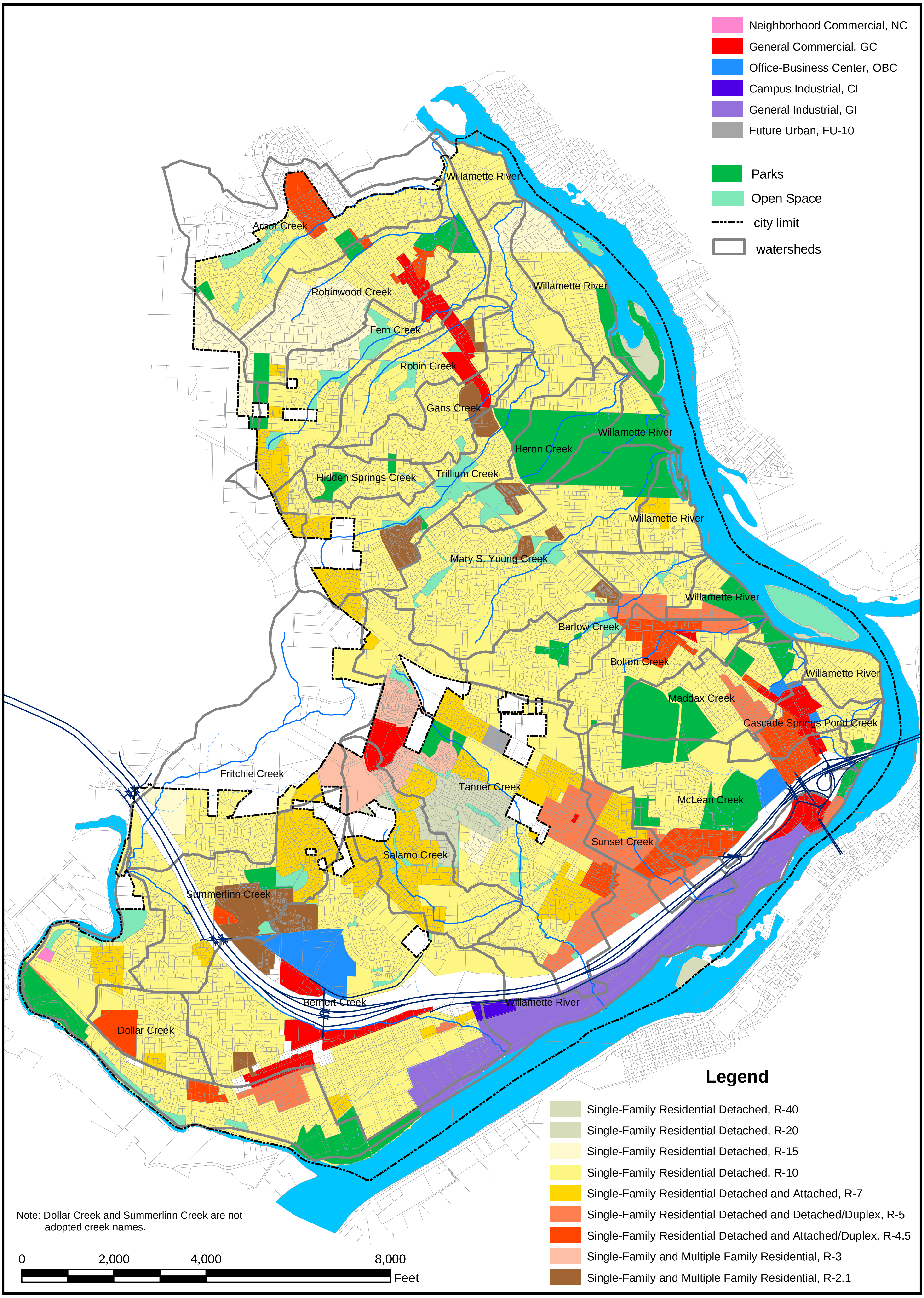
storm_mp2004\ground_slopes.mxd | Lee | 9-14-06 (from 8-10-04 draft)

Figure 3.2 Ground Slopes in the Study Area

Taxlot Base Source: Clackamas County GIS

Surface Water Management Plan 2006

West Linn GIS
GEOGRAPHIC INFORMATION SYSTEMS

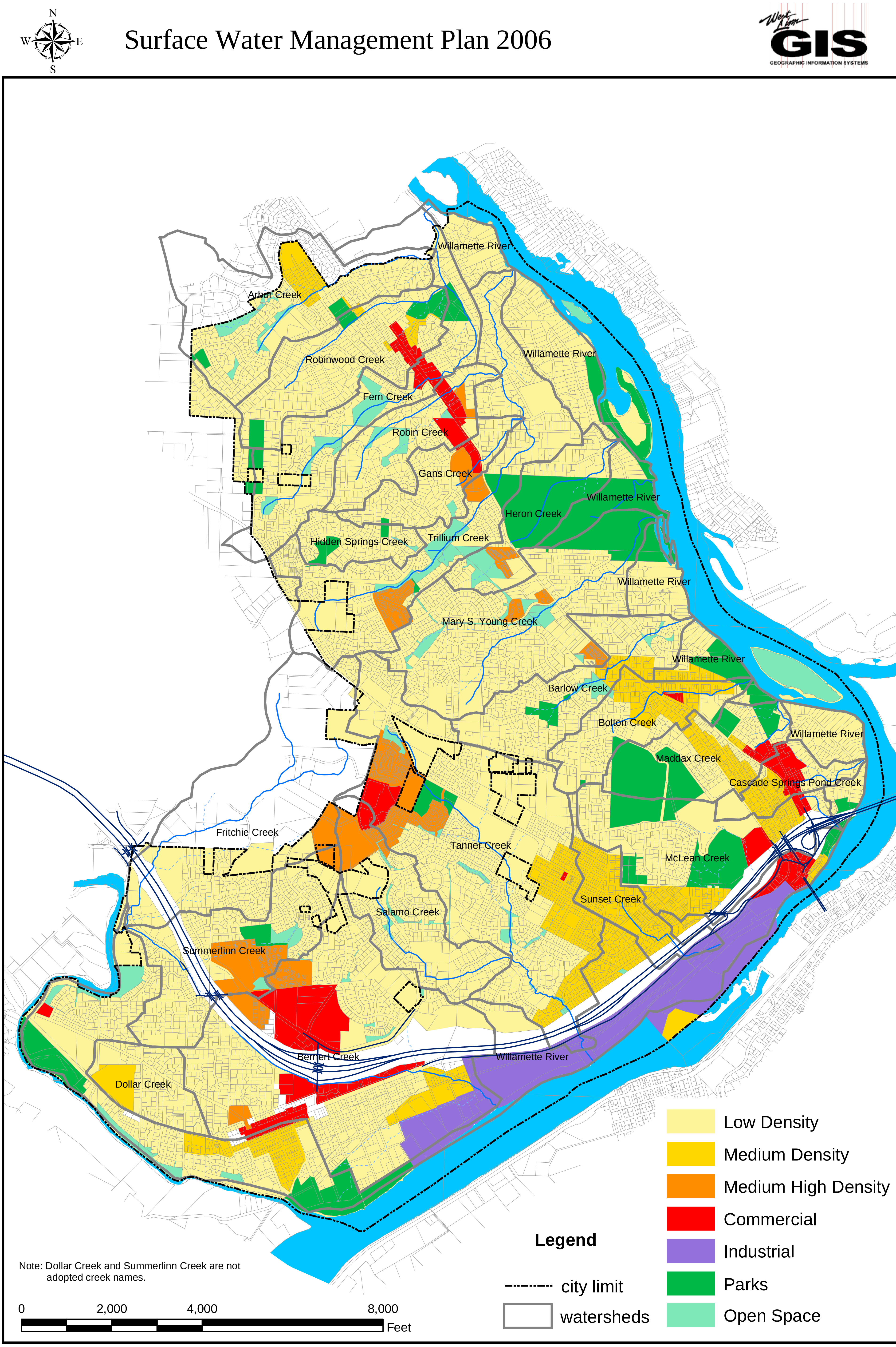


storm_mp2004\current_landuse.mxd | Lee | 9-14-06 (from 8-10-04 draft)

Figure 3.3 Current Land Use

Taxlot Base Source: Clackamas County GIS

Surface Water Management Plan 2006



storm_mp2004\comp_plan.mxd | Lee | 9-14-06 (from 8-10-04 draft)

This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Taxlot Base Source: Clackamas County GIS

Figure 3.4 Comprehensive Plan Land Use

Surface Water Management Plan 2006

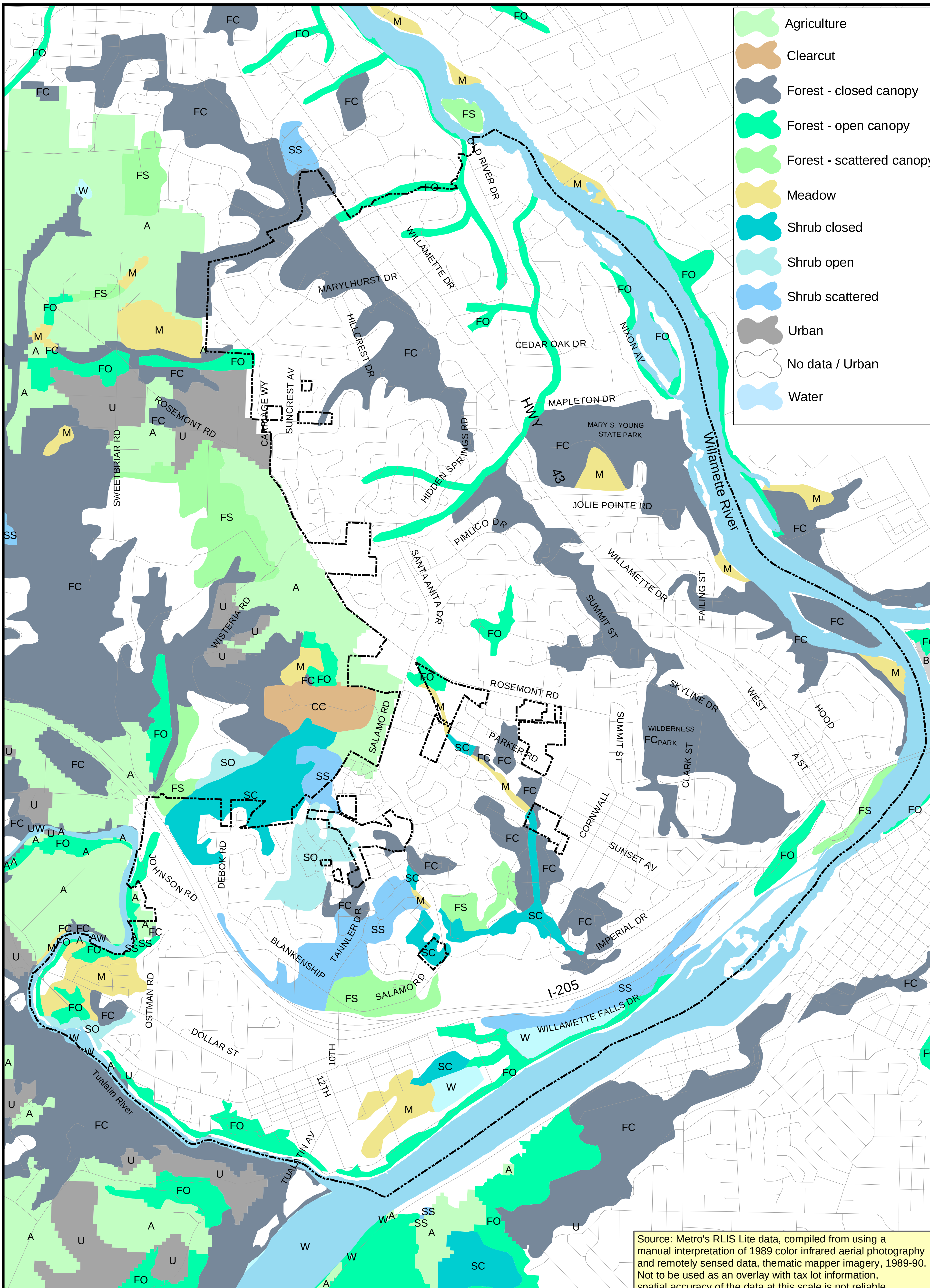
West Linn GIS
GEOGRAPHIC INFORMATION SYSTEMS

storm_mp2004\age_of_development.mxd | Lee | 9-14-06 (from 8-06-04 draft)

Figure 3.5 Age of Development

Taxlot Base Source: Clackamas County GIS

Surface Water Management Plan 2006



0 2,000 4,000 8,000 Feet

Figure 3.6 Vegetation Cover in the Study Area

This map and other information have been compiled for preliminary and general purposes. They are not intended to be complete and accurate for any other purposes. Specifically, this information is not intended to be complete for purposes of land use restriction, zoning, title, size, and suitability of the property for specific uses.

Taxlot Base Source: Clackamas County GIS

storm_mp2004\vegetation.mxd | Lee | 9-14-06 (original3-25-04)

N
W E
S

Surface Water Management Plan 2006

West Linn GIS
GEOGRAPHIC INFORMATION SYSTEMS

0 2,000 4,000 8,000
Feet

Figure 3.7 Soils in the Study Area

Taxlot Base Source: Clackamas County GIS

storm_mp2004\soils.mxd | Lee | 9-14-06 (original 3-25-04)

Surface Water Management Plan 2006

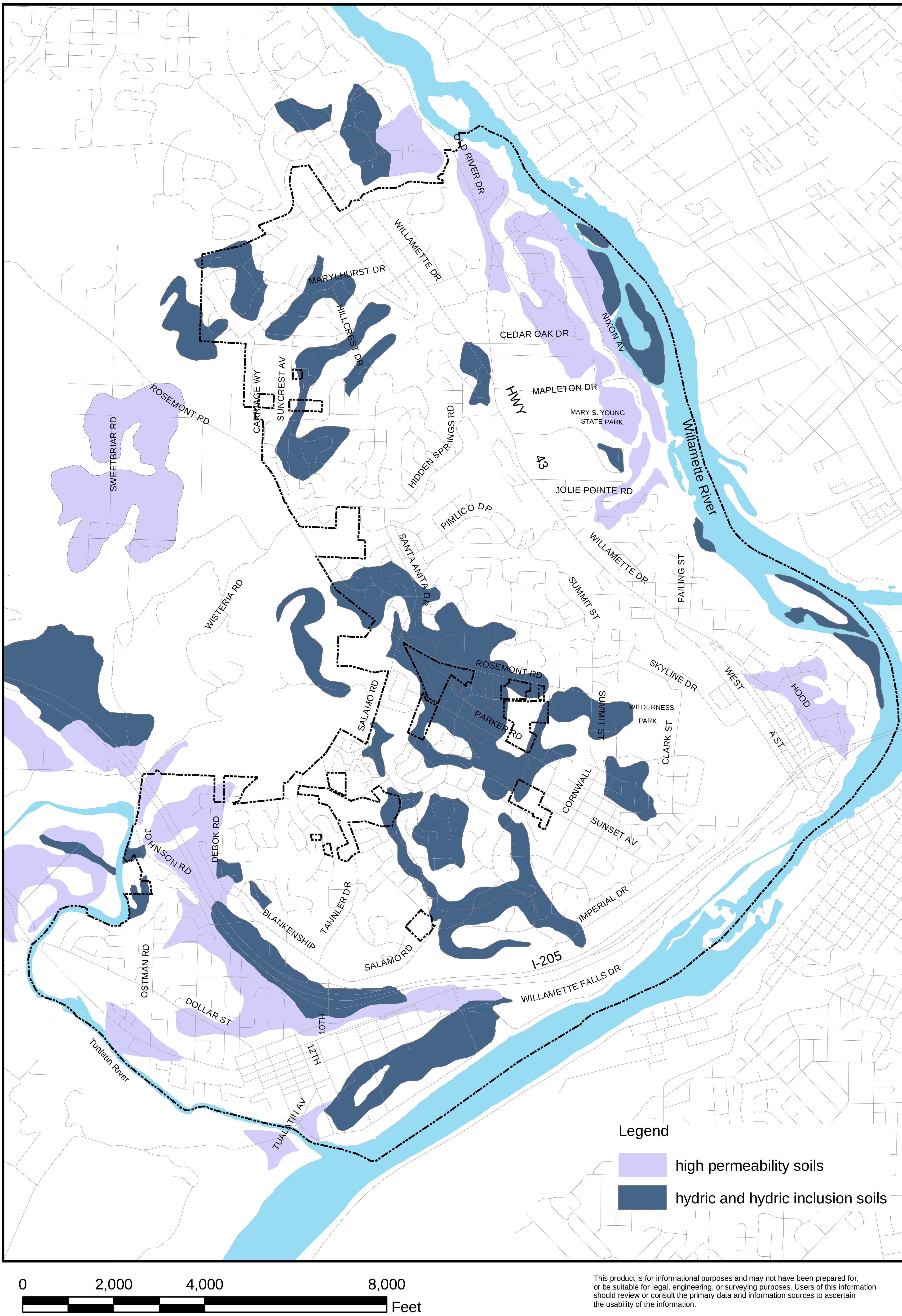
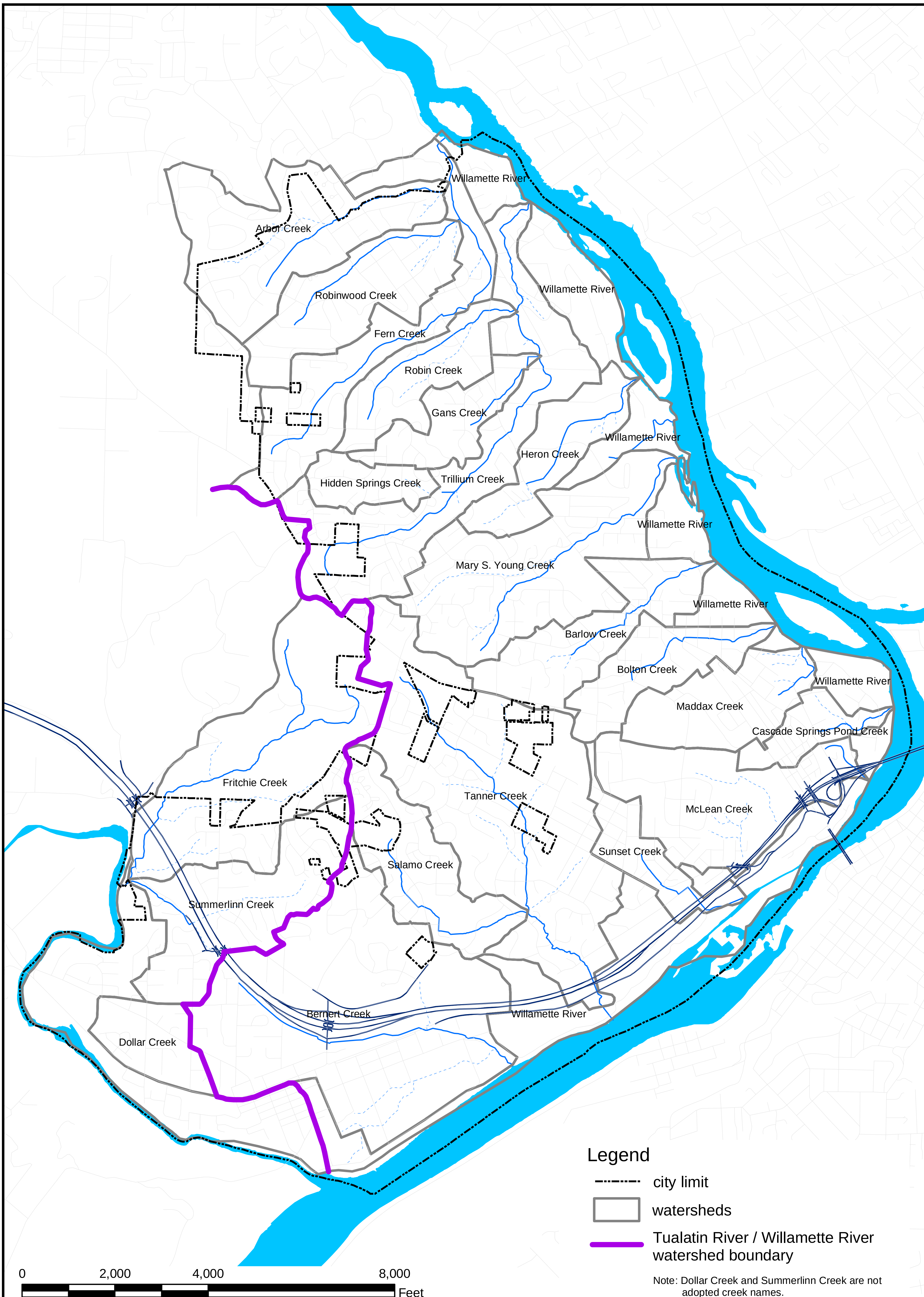


Figure 3.8 Hydric Soils and Permeable Soils in the Study Area

Taxlot Base Source: Clackamas County GIS

storm_mp2004\soils_perm_hydr.mxd | Lee | 9-14-06 (original 3-25-04)



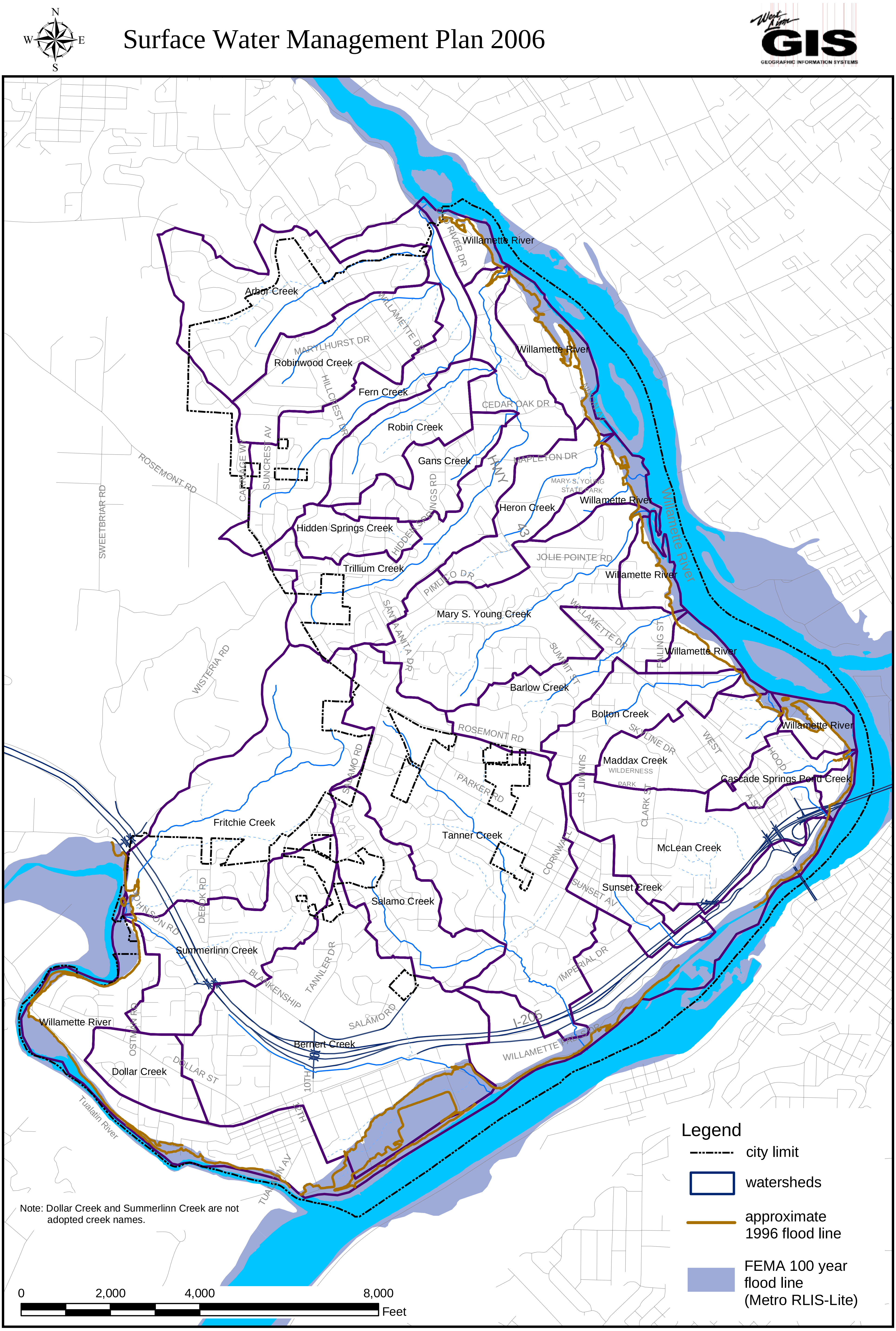
storm_mp2004\studyarea_watersheds | Lee | 9-14-06 (draft 8-09-04)

This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Figure 3.9 Study Area Watersheds

Taxlot Base Source: Clackamas County GIS

Surface Water Management Plan 2006



storm_mp2004\flood_management.mxd | Lee | 9-14-06 (draft 8-10-04)

Figure 3.10 Flood Management Area

Taxlot Base Source: Clackamas County GIS

Chapter 4

HYDROLOGIC AND HYDRAULIC ANALYSES

In a simplified undisturbed hydrologic cycle, precipitation falls from the sky, gets intercepted by vegetation, infiltrates into the rich duff layers of forest and prairies, recharges groundwater, and emerges in local streams and wetlands as baseflow.

With the loss of vegetation and disturbance of forest and prairie soils, precipitation is still infiltrated, but at a much lesser rate. Groundwater still recharges the streams and wetlands, but the retention time in the vegetation/topsoil sponge is less. Deep groundwater recharge may be affected and there are greater volumes of surface water runoff. With each incremental impact to the vegetation and soil structure, there are changes to the infiltration/runoff relationship

When the landscape becomes urbanized, impervious surface and stormwater drain lines replace the pervious natural conditions. The “hardscape” circumvents the typical hydrologic cycle. The loss of topsoil retention time and groundwater recharge results in less baseflow in the streams. An increase in the frequency and volume of runoff can damage the physical structure of stream channels and alter wetland hydroperiods. Storm events that were once absorbed by the landscape become “flashy” flows, rapidly rising and falling surface waters that correlate with passing storms. These higher flows reach stream systems faster. Undersized or blocked pipes only worsen the potential problems. They can flood road crossings and pose unacceptable risks to lives or property.

One of the principal objectives of any stormwater planning effort is the development of a hydrologic model to estimate peak flows and runoff volumes within the watersheds being studied. Peak flows are used to evaluate hydraulic capacities and potential deficiencies in existing culverts and closed pipe systems. Peak flows are also used to size open channels and pipe system needed to correct the identified deficiencies. Runoff volumes are used to size detention facilities.

4.1 HYDROLOGIC MODEL (HEC-HMS) DESCRIPTION

The hydrologic model used by Pacific Water Resources, Inc. (PWR) to estimate peak flows and volumes of stormwater throughout the study area was the Hydrologic Engineering Center’s Hydrologic Modeling System (HEC-HMS). The HEC-HMS model is a computational system used to simulate the precipitation to stormwater runoff process within a watershed.

The HEC-HMS program uses three components to create a working model of the watershed. They are called: the Meteorologic Model, Control Specifications, and the Basin Model. The Meteorologic Model is used to characterize the amount and distribution pattern of the precipitation. The Control Specifications contains the simulation dates and time interval used in the analysis. The Basin Model contains the physical characteristics of the watershed using various modeling elements. These elements include: basins (subbasins), reaches, junctions, reservoirs, diversions, sources, and sinks.

Precipitation (Meteorologic Model)
A precipitation hyetograph is a hypothetical time series of precipitation depths used to simulate a precipitation event. Precipitation can occur in the form of rainfall or snow. Snowfall in the Portland Metropolitan area rarely occurs since temperatures above freezing usually occur at lower elevations during the occurrence of wintertime wet weather events. For this reason, the precipitation used in the first component of the HEC-HMS model referred to as the Meteorologic Model was assumed to be entirely rainfall.

The duration of the design storm hyetograph used for drainage planning is extremely important. The rainfall duration will affect both the estimate of peak flow and total runoff volume. The most common rainfall durations used in drainage planning are 6, 12, or 24 hours.

Generally accepted design practice is that to maximize the estimate of peak flow, the rainfall duration should match as closely as possible the time of concentration at the point of interest within the watershed. The time of concentration is the time it would take runoff to travel from the farthest watershed divide to the point of interest.

With the continued development and application of watershed hydrologic models throughout the 1970s and 1980s, it became obvious that the duration of the design storm hyetograph needed to be set to a single value. This decision was based on the need to reduce cost and end public confusion regarding differing peak flows that would then result for a given return interval or percent chance of flooding (*i.e.*, 100-year, 6-hour peak; 100-year, 12-hour peak; 100-year, 24-hour peak; etc.).

An analysis by MGS Engineering Consultants as part of the comprehensive Watersheds 2000 project funded by Clean Water Services (CWS) of Washington County, Oregon, concluded that long duration storms (*i.e.*, 24 to 72 hours) are the type of storms that typically produce flooding with a sustained peak flow accompanied by a large runoff volume. The MGS study developed and recommended the use of two 72-hour duration precipitation hyetographs for single-event hydrologic modeling. In fact, the peak flows originally generated throughout the detailed HEC-HMS modeling of the major Tualatin River tributaries as part of the Watersheds 2000 project used one of the 72-hour design storms recommended by MGS.

However, comparisons of the resulting 72-hour peak flows to those published as part of the existing Washington County Flood Insurance Study (FIS) shows that the 72-hour peak flows were significantly less than the published FIS peak flows. The existing FIS peak flows were estimated years ago with simple hydrologic models using 24-hour duration design storms. Since PWR at the time was under contract to use the 72-hour peak flows as part of the huge Tualatin Basin Floodplain Remapping Project for CWS, many of the local jurisdictions were concerned about underestimating water surface elevations and the risk of flooding that could occur.

As a result, a separate analysis by PWR concluded that the 24-hour storm better reflects shorter rainfall durations that pose a much greater flooding risk in the smaller urbanized watersheds where most of the 167 waterway miles of remapping was occurring. The 24-hour SCS Type 1A design storm was recommended and accepted by the local jurisdictions for use as part of the remapping project for the reason noted above and the following two reasons:

- It is consistent with well-established engineering practice.
- It provides a greater level of safety to the public.

The design rainfall hyetograph pattern used in the development of the West Linn HEC-HMS models was the same SCS Type 1A storm used for the Tualatin Basin Floodplain Remapping Project. Table 4.1 lists the total 24-hour rainfall depths used in the development of the HEC-HMS hydrologic models and their associated return intervals and annual chance of occurrence for the twenty-one West Linn watersheds. The 2-year through 100-year precipitation values were estimated using the isopluvial maps published by the National Oceanic and Atmospheric Administration (NOAA) in the *Precipitation Frequency Atlas of the Western United States* (1973). The 500-year precipitation value was estimated by extrapolating the value based on a plot of the 2-year through 100-year precipitation values.

Table 4.1 24-Hour Rainfall Depths

Recurrence Interval (year)	Annual Chance of Occurrence (%)	Rainfall Depth (inches)
2	50	2.5
5	20	3.0
10	10	3.4
25	4	3.9
50	2	4.3
100	1	4.5
500	0.2	5.3

The annual chance of occurrence is the probability of occurrence or risk that, in this case, the 24-hour rainfall depths noted above will occur within any given year. The reciprocal of the annual chance of occurrence is called the recurrence interval. The danger of always referring to the recurrence interval when discussing the chance of rainfall depth and/or peak flow is that it implies to the layperson that since an infrequent event may have recently occurred, such as the February 1996 flood, that it will not likely occur again for a very long time. Unfortunately, this is not true and very misleading.

For example, the February 1996 flood peak on the Tualatin River at West Linn has been determined to be an 84-year return interval event whose annual chance of occurrence was 1.2%. Thus, the largest flood ever recorded in approximately 74 years of record on the Tualatin River still has a 1.2% annual chance of occurrence next year or in any given year. One should always refer to the annual chance of occurrence when discussing infrequent events such as the “1% chance flood” since it always provides an opportunity to explain this important term to a layperson.

As noted earlier, simulations using the HEC-HMS model were limited to a single design storm that is assumed to occur uniformly over an entire watershed. Precipitation over a large area is variable, however, and locations within a watershed may not experience the same amount of precipitation from the same storm. This is especially true in large watersheds (*i.e.*, greater than 50 square miles). Since each individual watershed is less than 5 square miles, no adjustment to the point rainfall depths were made.

HEC-HMS Control Specifications

The next component in the HEC-HMS model is referred to as the Control Specifications. The HEC-HMS model simulation for the West Linn watersheds were set to run for a 24-hour duration. An arbitrary starting date was set as January 1, 3000 at a time of 00:00, the ending time was set as January 1, 3000, 24:00. The year 3000 is used to indicate that due to a general lack of rainfall and flow data these models are not being calibrated to any known storm event. The time interval was set to 5 minutes. Therefore, the HEC-HMS models will compute a flow on the hydrograph every 5 minutes for the entire 24-hour duration. A hydrograph is a plot of flow versus time at a given point of interest within a watershed.

Basin Model
The final component in the HEC-HMS model is referred to as the Basin Model. The Basin Model contains the physical characteristics of the modeled watershed. A physical schematic of the watershed is created using watershed elements, which are subbasins, reaches, reservoirs, junctions, diversions, sources, and sinks. Each of these elements is linked together to develop a schematic representation of the actual watersheds. The West Linn HEC-HMS models used the subbasin, reach, junction, reservoir and sink elements. A brief general description of these elements now follows.

The **subbasin** element is used to identify the hydrologic properties or input parameters for a given small watershed area called a subbasin area. The element requires drainage area, a loss rate method, a transformation method and a baseflow method. The delineation of the subbasin areas are based on localized topography, streets, areas of concern and the existing stormwater collection system.

The **reach** element represents a conveyance system used to route or transport flow from one point downstream to another point in the watershed. The conveyance can be either an open channel or a closed pipe. The required input for a reach is the designation of a routing method to be used along with a shape, length, slope, cross sectional dimensions and roughness coefficient. A reach is needed to connect each of the junctions used in the watershed model.

The **junction** element represents a location within a watershed where one or more sources of flow are combined. The junction may represent two reaches combining , subbasins discharge into a reach or any combination of subbasin and reaches coming together. System reaches are used to connect the junctions through the watershed. There are no parameters required in the hydrologic model for junctions other than a name.

The **reservoir** element represents locations where flow can be stored which will lower or attenuate peak flow. Examples of reservoirs in West Linn include detention ponds and underground storage tanks. The required input for a reservoir is the relationship between total storage volume and outflow from the reservoir.

The **sink** represents an element that has an inflow but does not have outflow. It can be used to indicate the downstream terminus of a model where no elements exist further downstream. In West Linn, the confluences of the modeled creeks with one of the two major rivers are represented using a sink. Like the junction, the sink element does not require any input parameter except a name.

Basin Delineations
One of the most important steps in any runoff modeling involves delineating the physical watershed into major basins, subbasin areas, and the interconnecting network of major stream reaches. The starting point for the delineations of the West Linn study area were the subbasin boundaries previously identified by West Linn’s 1996 Stormwater Master Plan. During the redelineation, however, care was taken to consider the affect on drainage by roads that traversed slopes and by piped drainage systems that could flow against the grade. Finally, drainage divides in some very flat areas were resolved during the field reconnaissance of the hydraulic structures.

As stated earlier, a total of twenty-one (21) major basins or watersheds were identified within the West Linn study area. Each basin was named primarily by the City and assigned a unique two-letter code based on that name. The names of all of the hydrologic elements located within a given major basin would start with the basin’s two-letter code. By using a naming convention such as this, one would always know where the element is generally located. Table 3.2 lists the names and two letter codes for the twenty-one basins and streams throughout the study area. Stevens Creek (*i.e.*, ST) was not included in the table since it is a small upland tributary of Fritchie Creek (*i.e.*, FR) as noted earlier.

Table 4.2 Stream Names and Two-Letter Basin Codes

Stream Name	Code
Arbor Creek	AR
Barlow Creek	BA
Bernert Creek	BE
Bolton Creek	BO
Cascade Springs Pond Creek	CS
Dollar Creek	DO
Fern Creek	FN
Fritchie Creek	FR
Gans Creek	GS
Heron Creek	HE
Hidden Springs Creek	HS
Maddax Creek	MX
McLean Creek	MC
Mary S. Young Creek	MY
Robin Creek	RB
Robinwood Creek	RW
Salamo Creek	SA
Summerlinn Creek	SL
Sunset Creek	SS
Tanner Creek	TA
Trillium Creek	TR

Subbasin Naming
A total of 256 subbasin areas were eventually delineated with an average drainage area of 17 acres. Subbasin areas were assigned IDs based on the major basin they were located within and their respective location within that basin. Starting with the two-letter basin codes, the subbasin areas were numbered starting with "1" for the most downstream subbasin area. Moving upstream the subbasin number increased up to "9". If the number of subbasins exceeded "9", the tenth and higher were assigned letter codes starting at "A". For example, TA5 is the fifth subbasin area contributing to Tanner Creek counting upstream from the mouth.

For subbasin areas not directly tributary to the main channel, a directional code (<u>N</u>orth, <u>S</u>outh, <u>E</u>ast or <u>W</u>est) was added to the downstream number/letter code starting once again with the number "1" denoting the farthest downstream tributary subbasin area combining with the previously numbered main channel subbasin area from the direction noted. For example, TA5E1 designates a Tanner Creek subbasin area that is on an eastern tributary (*i.e.*, "E") that joins Tanner Creek subbasin "TA5" at the most downstream location (*i.e.*, "1") on this tributary. Subbasin TA5E2 would be similar, but it would designate the next upstream subbasin area on this eastern tributary to TA5.

Junction Naming
Junctions were identified by the subbasin area connected to it by adding a "J" after the two-letter basin code followed by the number sequence explained above. For example, TAJ5 is the junction where the

flow from subbasin TA5 enters Tanner Creek. TAJ5E2 is the junction where the flow from subbasin TA5E2 enters this eastern tributary of Tanner Creek which eventually enters Tanner Creek at TAJ5.

Reach Naming
The naming convention for the reaches within a basin model is based on the upstream and downstream junctions that are joined. An "R" is placed after the two-letter basin code followed by the alphanumeric code for the downstream junction then a hyphen followed by the alphanumeric code for the upstream junction. For example, the reach connecting junction TAJ5 to the downstream junction TAJ4 would be TAR4-5.

Figure 3.1 shows the location of the subbasin boundaries for the 256 subbasin areas delineated as part of the twenty-one major basins that were modeled. (All of the figures for this chapter can be found at the end of the text.) Figure 3.2 shows the locations of the junctions and reaches identified throughout the West Linn study area.

4.2 HEC-HMS INPUT PARAMETERS

This section will briefly discuss the input parameters to the various HEC-HMS models and the methods used to compute them.

Soil Infiltration
When precipitation reaches the ground it can do one of three things; infiltrate into the ground, go into storage, or generate runoff. When precipitation falls on a pervious surface, the infiltration capacity of the soil controls whether the precipitation becomes runoff or is infiltrated. As long as the precipitation rate is less than the infiltration rate of the soil, there will not be surface runoff generated. Precipitation events associated with thunderstorms generally have high enough intensities to generate surface runoff. Winter storms along the Pacific Coast of the United States typically are low intensity precipitation events, occurring over a period of days. These storms likely will not produce high enough intensities to generate surface runoff on pervious soils. The runoff experienced in this region for undeveloped watersheds is the result of infiltrated precipitation resurfacing from shallow subsurface flow or interflow.

One of the loss rate methods provided in HEC-HMS is the Soil Moisture Accounting (SMA) method. SMA is a conceptual model that represents how rainfall enters the soil columns as a series of reservoirs. The reservoirs are canopy interception, surface storage, soil storage, and two groundwater layers of storage. The HEC-HMS program requires the use of a loss rate method to effectively simulate the relationship between precipitation rates and infiltration. The loss rate method used for the West Linn study area was the SMA method.

The SMA parameter values used for the soils in the West Linn study area were based on the final calibrated values from PWR's HEC-HMS modeling of Tualatin River tributaries referred to as the Watersheds 2000 Project for CWS. These SMA input values were based on a calibration of two Hydrocomp Simulation Program Fortran (HSPF) models and HEC-HMS models to observed stream flow data for Bronson Creek and Fanno Creek in Washington County, Oregon.

Effective Impervious Area (EIA)
Impervious area such as rooftops, streets, sidewalks, and parking areas do not allow water to drain into the soil. Impervious area that collects and drains the water directly to a stream or wetland system via pipes or sheet flow is considered "effective impervious area" because it effectively drains the landscape. Impervious area that drains to landscaping, swales, parks and other pervious areas is considered to be "ineffective" because the water is allowed to infiltrate through the soils and into groundwater without a direct connection to the stream or wetland.

Effective impervious area (EIA) is very important because of the influence it has on both the quantity and quality of runoff from urbanized areas. Research conducted by the University of Washington and the Center for Watershed Protection in Maryland indicates that the biological productivity of streams declines significantly once effective impervious area reaches 10-20% of a watershed's total contributing area. Therefore, EIA becomes a major factor in light of the ESA listings and its potential effect on aquatic species.

Although little direct infiltration occurs on impervious surfaces, losses to interception, storage, or infiltration via adjoining pervious areas can still be significant. As a result, the EIA used to model runoff is normally a fraction of the total Mapped Impervious Area (MIA). MIA represents the total portion of a watershed or subbasin where the soil is covered by pavement, buildings, or similar impermeable surfaces. It does not consider such factors as overhanging vegetation, local depression storage, or indirect drainage by way of pervious areas.

For each subbasin runoff element, EIA is computed after first estimating the corresponding MIA. EIA is modeled as a fraction of MIA that varies depending on the local conditions and drainage system. For the West Linn study, the Sutherland EIA Equation (Sutherland, 2000) was used to model EIA from MIA. The Sutherland EIA Equation was developed from USGS measured MIAs and EIAs for the Portland area that were observed by relating runoff volumes to rainfall depths for basins of varying development and drainage and ranging in area up to 25.6 square miles.

Table 4.3 shows the EIA values that were assigned to each of the GIS zoning coverages found throughout the West Linn study area. Table 4.4 presents the results of the EIA modeling by major basins throughout the study area for both existing and future land use conditions. Future conditions are taken from the 2000 comprehensive plan and are associated with planned zoning.

Table 4.3 GIS Zoning Coverage and Percent Effective Impervious Area Per Category

Zoning Category	Abbreviation	Percent Effective Impervious Area (EIA)
Water	WAT	100
Roads	RDS	85
Industrial	IND	85
Commercial	COM	85
Multi-Family Residential	MFR	35
Single-Family Residential	SFR	21
Vacant	VAC	0
Rural Residential (County Lands)	RUR	2
Public Open Space	POS	0
Forest	FOR	0
Shrub	SCR	0
Meadow	MED	0

Table 4.4 Effective Impervious Areas (EIA) of HEC-HMS Modeled Watersheds

Watershed	ID	Watershed Area (acres)	Existing Conditions Effective Impervious Area (acres)	Existing Total Percent	Future Conditions Effective Impervious Area (acres)	Future Total Percent
Arbor Creek	AR	264.9	29.5	11%	31.9	12%
Barlow Creek	BA	156.5	25.5	16%	31	20%
Bernert Creek	BE	576.8	241	42%	259.5	45%
Bolton Creek	BO	113.3	20.8	18%	23.7	21%
Cascade Spgs Pond Crk	CS	57.1	20.2	35%	20.2	35%
Dollar Creek	DO	78.4	16.1	21%	16.5	21%
Fern Creek	FN	225.6	34.2	15%	38.4	17%
Fritchie Creek	FR	389.1	36.1	9%	46.8	12%
Gans Creek	GS	89.6	21.6	24%	22.1	25%
Heron Creek	HE	114.4	9.7	8%	12.7	11%
Hidden Springs Creek	HS	56.5	10.4	18%	10.4	18%
Maddax Creek	MX	137.7	19.5	14%	21	15%
Mary S. Young Creek	MY	312.4	49.9	16%	57.2	18%
McLean Creek	MC	227.4	65.6	29%	65.6	29%
Robin Creek	RB	115	29	25%	31.7	28%
Robinwood Creek	RW	175.9	35.2	20%	38.3	22%
Salamo Creek	SA	163	32.2	20%	38.1	23%
Summerlinn Creek	SL	213.7	53.2	25%	59.4	28%
Sunset Creek	SS	76.2	28.3	37%	28.3	37%
Tanner Creek	TA	537.1	114.1	21%	132.3	25%
Trillium Creek	TR	305.6	51.2	17%	59.4	19%
Totals		**4386.2**	**943.3**	**22%**	**1038.5**	**24%**

Transformation Method

Precipitation that is not infiltrated becomes surface runoff also referred to as excess precipitation. This process is referred to as the “transformation” of precipitation to runoff. For the West Linn Surface Water Management Plan, the Snyder Unit hydrograph method was used. The Snyder method is an empirical unit hydrograph developed in 1938 to estimate peak flows for ungauged watersheds in the Appalachian Highlands. This method uses two parameters, a standard lag and a peaking coefficient, to independently modify the lag time and hydrograph skew, respectively. Other methods either do not model hydrograph skew (*e.g.*, the SCS dimensionless unit hydrograph method), do not allow for the independence of lag time or skew (*e.g.*, the Clark Unit Graph), or require considerably more computation and calibration, yet provide no additional information (*e.g.*, the Kinematic Wave).

The unit hydrograph represents the runoff of a basin that would result from an almost instantaneous burst of rainfall, and is normalized by the runoff volume and by the lag time between peaks of rainfall and runoff. Thus, the normalized lag time and area would be 1.0. The method then predicts the runoff for any rainfall event by dividing the rainfall into individual time intervals and totaling the hydrograph response from each rainfall time slice. Alternatively, the runoff at any time represents an average of the prior rainfall, weighted by this unit hydrograph.

The lag time of a watershed (subbasin) is the duration between the center of mass of the precipitation event and the center of mass of the resulting runoff/flow. For hydrologic modeling, lag time is used to transform (shift) the empirical unit hydrograph, with respect to time. In order to replicate actual flow this adjusted unit hydrograph is used to compute lag time. The lag time was determined for all of the subbasins in the study area.

The methodology used to compute lag times for the West Linn study area was based on a paper entitled "Methodology for Estimating Lag Time of Natural, Partially Urbanized and Urban Watersheds Based on Published U.S.G.S. Data for Watersheds throughout the Metropolitan Areas of Portland and Salem, Oregon" (Sutherland, 1988). The Sutherland Lag Time Equation described in this paper was based on observations of lag times by the USGS from subbasins with urbanization ranging from undeveloped or rural to highly urban and with areas ranging from 0.2 to 26.5 mi^2.

The equation computes the lag time of a watershed based on easily measured or estimated physical characteristics. The variables used for the lag time determination are flow length (piped and/or open channel), subbasin slope, land use, and mapped impervious area. The Map5 and Land Development modules for AutoCAD were used to determine the estimated parameter values. The GIS component of Map5 analyzed the zoning coverage for the study area to determine the land use classification and mapped impervious area for each subbasin. The flow length and whether it was piped or open channel was calculated from the storm system coverage map of West Linn. The slope of each subbasin was estimated based on 2001 Metro contour data.

The Snyder Peaking coefficient (Cp) allows for altering the peak flow generated by the unit hydrograph. The Cp parameter is used to assist in the calibration of a hydrologic model. The normal range of Cp is between 0.4 and 0.8. By lowering the value, the resulting hydrograph has a lower peak but extends for a longer period of time. If a high Cp value is used, the hydrograph appears very spiky with a shorter duration. The altering of Cp does not change the total hydrograph volume. No calibration data is available for the West Linn study area so the Cp value was set based on experience gained in detailed calibrations to similar watersheds in the Portland area. The developed condition Cp was set to 0.4 based on this information.

Baseflow

Precipitation that infiltrates and passes through the upper levels of the soil enters the groundwater. Groundwater is the principal source of streamflow during the drier periods of the year. Groundwater flows down gradient and sometimes surfaces in streams and springs. The groundwater that returns to the stream is referred to as baseflow. The Soil Moisture Accounting (SMA) method for infiltration assumes groundwater will return to a stream as baseflow. The Linear Reservoir method was used to incorporate baseflow into the hydrologic models.

The Linear Reservoir method models groundwater flow as storage and discharge from reservoirs. Groundwater layer 1 of the SMA provides the inflow into one reservoir and Groundwater layer 2 provides inflow into the other. The outflow from the two reservoirs is combined to form the baseflow component. The amount of storage available in each reservoir is based on the storage capacity given in the subbasin SMA values and storage coefficient (attenuation) given in the Baseflow Method file. The SMA values used in the West Linn project were based on experience gained through the calibration of several HEC-HMS models as part of the Watersheds 2000 Project.

Reaches

Downstream routing of flow hydrographs through the watershed model is carried out using reaches. The reaches represent all forms of conveyance including storm pipes, channels (ditches/streams), and reservoirs (ponds/lakes). For pipes and channels, the Muskingum-Cunge (MC) Method was used to model the attenuation of the hydrograph because it is physically based.

The MC method is based on the concepts of continuity and momentum and uses the reach channel geometry, length, slope, and Manning's 'n' values to estimate water surface elevations and velocities in the channel. By dividing the channel into slices along the reach length, the MC method can account for storage volume within the channel and overbank area. In-channel storage could be capable of attenuating the flow hydrograph as the flow migrates downstream. The velocity calculated using the MC method is used to assist in determining the timing of combining hydrographs as new subbasins contribute flow to the reaches.

For the West Linn study area, the channels are both so steep and so confined that instream storage is not a major contributor to flood protection. But the MC method was still used because it allows for the modeling of the conveyance system with actual physical parameters.

Shape is used to describe whether the conveyance system is a pipe or open channel. For pipes, the shape can either be circular or box. For open channels, it can be rectangular, trapezoidal, or natural. If the channel is a natural irregular shape, the input allows a set of eight data points to describe the channel and overbank shape. The GIS data for the storm sewer collection system was used to determine the initial type of conveyance system. If the conveyance was a pipe, the size was taken from the West Linn dataset. If the conveyance system was an open channel, then the geometry of the channel was gathered either from the City's 1996 SWMM model or most likely determined from a field visit.

The length of the conveyance systems between junctions in the HEC-HMS model was generally estimated from the storm sewer data provided by the City. The slope of the conveyance was estimated with the use of the Metro 2000 5-foot contour topographic data. Manning's 'n' values are well known for closed pipe conveyances once the material has been identified and were empirically derived for open conveyances.

Input Parameter Values

Select input parameter values used for the HEC-HMS modeling of the twenty-one major basins throughout the West Linn study area are presented in Appendix A. Input parameter values for EIA, lag time and soil infiltration are tabulated for each of the 256 subbasin areas for both existing and future land use conditions.

4.3 MODEL CALIBRATION

Model calibration is the process of refining input parameters on a consistent basis to optimize the ability to reproduce observed data while maintaining the greatest physical basis underlying the input parameter selection. Unfortunately, there are no continuous recording streamflow gages in the West Linn study area for the modeled streams. Therefore, there is no specific data available for model calibration.

In situations such as these, it is important to determine whether the peak flows from the models appear to be reasonable and within the range of variation that can be expected. One parameter that can be used to check a model for reasonableness is the unit peak discharge. A unit peak discharge is defined as the peak discharge divided by the total watershed area at the same location. Unit peak discharge decreases with increased drainage area. They also increase with increasing EIA and increasing watershed slope.

The unit peak discharges from the West Linn models were compared to the values obtained from the calibrated HEC-HMS model of Fanno Creek created by PWR as part of the Watersheds 2000 Project funded by CWS of Washington County, Oregon. As part of that project, the Fanno Creek model was calibrated to observed streamflow data at two locations from four separate flood events that occurred from February 1994 to February 1996.

The results of this comparison between West Linn flows and Fanno Creek flows are presented in Figure 4.3**.** The figure is called a scatter diagram because it shows the scatter of the unit peak discharges plotted against drainage area. The 25-year return interval or the 4% annual chance flood has been shown although the other floods were also checked. The 24-hour, SCS 1A storm distribution was also used in the Fanno Creek Project. The 4% annual chance flood was chosen since it was within the mid range of the floods simulated with the HEC-HMS models.

Figure 4.3 clearly shows that the unit peak discharges for the West Linn HEC-HMS models compare favorably with those from Fanno Creek HEC-HMS model that was calibrated to observed flood events. In fact, the average unit peak discharge for the West Linn dataset is 244 (cfs/mi^2). Whereas, the Fanno Creek average unit peak was 236 (cfs/mi^2) for those drainage areas less than 2 mi^2.

4.4 WATERSHED PEAK FLOOD FLOWS

The peak flood flows for the 50%, 20%, 10%, 4%, 2%, 1%, and 0.2% annual chance floods throughout each of the twenty-one major basins throughout the West Linn study area are presented in Appendix B. Peak flows for each of the seven design storms are tabulated for each of the modeled subbasins, junctions and reaches for both existing and future land use conditions. The peak flows for the Salamo (SA), Summerlinn (SL) and Tanner (TA) watersheds reflect the impact of the numerous stormwater detention facilities that exist in these watersheds. The stormwater detention analysis used to develop the flow reduction effectiveness of these facilities is described later in this chapter.

4.5 DRAINAGE PLANNING CRITERIA

The establishment of drainage planning criteria used in the development of a surface water management plan is an important process. Planning criteria establishes an acceptable level of protection against flooding. This acceptable level of protection is then compared against the estimated risk of flooding throughout the major drainage system. When the estimated flood risk is greater than the accepted risk threshold, various alternatives available to mitigate flooding must be analyzed. The choices are then to either increase the level of protection such that it satisfies the criteria or to do nothing and consciously accept a lower level of protection than that specified in the criteria.

As discussed earlier, both flood risks and level of protection against those risks are measured using the concept of storm recurrence interval or return period and its reciprocal function, the probability of exceedance. If one designs a hydraulic structure using a 100-year storm recurrence interval, the probability that the design flow will be exceeded in any given year is only 1 percent, so the level of protection against flooding would be very high. If the design was based on a 2-year storm recurrence interval, the probability of exceedance would be very high (50 percent probability in any given year) and the level of protection would be low. The obvious trade-off in the planning and design of drainage facilities is the cost of the facility. A facility designed to withstand a 100-year flood peak will cost considerably more than one designed to only pass the 2-year flood.

The flood planning criteria that is established essentially defines when a problem is assumed to exist. In a simple sense, it defines when something is broken and needs to be fixed. When establishing criteria, it is appropriate to discuss the specific nature of the flooding problem. For example, if the problem involves floodwaters overtopping the road, the type of roadway becomes an important issue. The desired level of protection for a major highway or arterial could be quite different from that for a residential collector street. Also, the desired level of flood protection for homes and businesses could be quite different from that for a parking lot or roadway.

Table 4.5 provides an example of a drainage planning criteria that could be used to identify deficient structures, and to design replacements. For several types of flood risk, it lists the maximum frequency of flooding above which a deficiency would be identified, and the minimum frequency design flow that must be safely passed after construction of the mitigating project.

Table 4.5 Example of Flood Risk Planning Criteria for Assessing Deficiencies

Type of At-Risk Structure or Property	**Existing Condition Must Safely Pass:**	**Improved Condition Must Safely Pass:**
Roadway Culvert or Bridge		
Local Collectors *(e.g., residential street)*	5-yr	25- or 100-yr*
Minor Arterial *(e.g., Salamo Rd.)*	10-yr	25- or 100-yr*
Major Arterial *(e.g., Hwy 43)*	25-yr	25- or 100-yr*
Freeway *(e.g., I-205)*	50-yr	100-yr
Buildings		
Houses or Apartments	100-yr	100-yr
Commercial, Industrial, or Institutional	100-yr	100-yr
Other: Garages, Sheds, or Other Outbuildings	25-yr	25-yr
Open Spaces		
` School Yards	10-yr	10-yr
Backyards	5-yr	5-yr
Active Parks *(e.g., Greenway Park)*	2-yr	2-yr
Natural Parks *(e.g., Fanno Creek Park)*	1-yr	1-yr
Golf Courses	1-yr	1-yr

* Note – See City Design Standard No. *2.0014 Culverts*, for more detailed information.

4.6 STORMWATER DETENTION

The City of West Linn requires new development to address the impacts urbanization has on peak stormwater runoff rates. Currently, the City requires storm detention facilities to provide enough storage to reduce peak flows up to the 25-year storm event with safe overflow conveyance of up to the 100-year storm event. Allowable post-development site discharge rates for the 2, 5, 10, and 25-year storm events are specified to be that of the pre-development rates. To achieve this goal, in most cases, V-notch weirs or multiple orifices are the method of choice. The City limits the smallest orifice diameter to 1.0 inch because of concerns about clogging. Therefore, when small sites are developed using a single detention facility, the minimum orifice diameter could result in little or no flow control for very frequent events such as the 2-year or 5-year storm events.

The City of West Linn provided GIS coverage of known detention facilities within the study area. The coverage contained 78 designated detention facilities. Eleven (11) facilities were located near the downstream extent of the watersheds close to their confluences with the Willamette and/or the Tualatin River.

Within the Tanner (TA) and Salamo (SA) watersheds, there are multiple in-line facilities. Generally these facilities serve more than one subbasin. Their construction generally consists of a structure (dam) designed to span the entire stream channel in order to create a pond on the upstream side. Outflow from the facilities is controlled by culverts. Many of the detention facilities were not located near the outlet of a modeled subbasin and as a result did not provide detention for the entire delineated subbasin.

A review of the location of the ponds/tanks and the upstream stormwater collection systems designated 26 stormwater detention facilities for analysis. All of the facilities provide stormwater detention for a single subbasin, which made the analysis easier since the subbasin would not have to be further subdivided. The locations of the analyzed facilities are shown in Figure 4.4, along with the remaining facilities located within the city that were not included in the analysis.

An analysis of the efficiency of the detention facilities within the City was conducted using stormwater design documents from recent developments. The City provided PWR with several reports that described the hydraulic design of various stormwater detention facilities in the Tanner Creek basin. The facilities examined, were essentially designed to reduce the 10-year peak post-development flows to their estimated 10-year peak pre-development condition. It was determined from computer simulation that the detention facilities provide for about a 50% reduction in peak flows at the 10-year post development storm level.

Since no construction details were available for most of the other detention facilities, this 50% reduction value was applied to all 26 detention facilities studied and a generic detention pond was developed. Based on the attenuation analysis, it was determined the detention volume required to adequately provide for the stormwater detention is approximately 0.0163 ac-ft/ac. Using this value, a single pond was created based on the largest analyzed subbasin. Extra volume was added to the pond to provide for attenuation of storm events larger than 10 years.

The outlet structure for the attenuation of the 10-year storm event was set as an orifice. The required orifice size for the individual detention facilities was calculated by estimating the required volume used in the generic detention pond and then determining how deep the water would get in the pond. Based on the allowable outflow and the driving head, an estimated orifice size was developed. Once all the ponds were added to the HEC-HMS models and the models were run, the orifice size was modified to provide the allowable pre-development 10-year outflow (50% reduction in post development peak flows).

The detention facilities were also analyzed for storm events larger than the 10-year design storm. For these events, an emergency overflow weir was placed at a level in the ponds just above the peak level of the 10-year event. The weirs are not intended to control the flow rate but instead they provide a controlled outflow from the pond. Because of this, the pond efficiency at attenuating the larger storm events is much lower than the 10-year design storm for which they were designed.

Table 4.6 lists the reduction in flows that will occur for the 2-year through 500-year storm events for the subbasins where detention facilities essentially serve the entire drainage area. As designed, the detention ponds are most efficient for the 10-year event, an average reduction in peak flows of 52%. Once the water level in the ponds reaches the overflow weir, the attenuation drops to 22% for the 25-year event and for the 500-year event the pond only provides 3% reduction in flow.

Table 4.6 Estimated Peak Flow Reduction Effectiveness for Various Stormwater Detention Facilities

Subbasin	Percent Peak Flow Reduction						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
TA5	45	50	53	24	18	11	4
TA6W1	50	52	54	21	16	9	2
TA6W1N	44	50	52	24	19	12	4
TA7W1	44	50	53	26	20	12	4
TA7W2	43	49	51	20	15	10	4
TA8E1	39	46	49	23	17	11	5
TA8W3	54	58	60	16	12	4	0
TA9	53	58	60	27	21	14	6
TA9E2	47	50	52	24	18	12	4
TA9E3	45	50	53	23	17	10	3
TAC	35	43	46	22	17	11	4
TAD	40	47	50	20	15	9	3
SL9W	53	54	54	27	19	12	1
SL9	43	49	52	20	14	8	2
SL8S1	49	52	53	22	16	7	2
SA9	48	53	56	20	16	9	2
SA7W	41	47	36	14	10	6	1
SA5N1	47	53	55	23	18	12	5
SA4	42	48	50	30	23	15	7
MY4S3	44	49	52	19	14	8	2
FR3S2	47	50	52	18	13	7	2
FNA	42	50	52	12	6	1	4
BE8	41	48	51	23	18	11	5
BE7	43	50	52	19	14	8	2
BE5W1N1	57	58	60	32	25	15	4
BE4N1	46	51	52	24	18	12	5
AVERAGE	**45**	**51**	**52**	**22**	**17**	**10**	**3**

Three watersheds with multiple detention facilities located within them were analyzed to determine the downstream impact of detention facilities. The three watersheds are Salamo (SA), Tanner (TA), and Summerlinn (SL). The analysis looked at stream reaches downstream of subbasins controlled by detention facilities along with the percentage of area within the tributary area impacted by detention. Table 4.7 presents the resulting peak flows estimated for the various HEC-HMS stream reaches in these three watersheds with and without detention facilities.

As expected, it was found that stormwater detention implemented in portions of a watershed will impact all areas downstream of the detention facilities. The largest impacts from detention facilities will be for locations with the largest percentage of total area controlled by stormwater detention ponds, and the storm event with the largest impact will be the design storm used to develop the detention facility. Table 4.7 illustrates that as the percentage of a watershed controlled by detention facilities increases so does the reduction of peak flow rates generated during storm events.

Table 4.7 Estimated Reach Peak Flows With and Without (w/o) Detention

Reach HMS_ID	Percent of Area Detained (%)	10-Year			25-Year			100-Year		
		Peak Flow (cfs)		% Flow Decrease	Peak Flow (cfs)		% Flow Decrease	Peak Flow (cfs)		% Flow Decrease
		w/o	with		w/o	with		w/o	with	
SLR7-8	48.9	16	10	33	21	17	18	24	23	6
SLR6-7	40.9	19	13	28	25	20	18	29	27	6
SLR5-6	37.8	20	15	26	27	22	19	32	30	6
SLR4-5	28.1	30	25	17	40	33	17	46	43	6
SLR3-4	24.2	37	32	14	48	41	15	56	52	7
SAR3-4	63.8	38	24	36	50	35	29	57	47	18
SAR2-3	60.5	39	26	35	51	37	28	58	49	17
SAR1-2	52.7	45	32	30	59	43	27	68	57	17
SLR2-3	15.6	62	57	7	80	74	8	92	85	8
SLR1-2	14.4	67	63	6	87	81	7	100	93	7
TAR4-5	41.9	160	120	25	211	164	22	245	210	14
TAR3-4	39.2	175	134	23	229	179	22	266	229	14
TAR2-3	36.8	186	146	22	245	192	22	285	246	14
TAR1-2	36.2	190	149	21	250	196	22	290	251	14

It is important to remember, values shown in Table 4.7 are representative of detention ponds that were apparently designed to attenuate the 10-year storm event and involve multiple events up to the 25-year. New detention facilities designed to the current, more stringent standards are expected to provide even greater peak flow reduction for the drainage areas that they serve.

4.7 HYDRAULIC CAPACITY

The hydraulic capacity of the pipes and culverts determined to be major facilities were analyzed as part of the stormwater planning process. Major facilities are defined as those draining two or more subbasin areas. Pipes and culverts with inadequate capacity can create localized flooding. In most cases the localized flooding is more of a nuisance, but under certain conditions it can cause significant damage. An undersized culvert may cause flow to overtop the road. As flow crosses the road, driving may become more hazardous. Also, the impact of flow on road fill may cause damage requiring repair and increased maintenance. The determination of the major facilities within the study area was conducted using the City of West Linn stormwater system coverage and the delineated drainage subbasins. Two hundred forty-five (245) total pipes and culverts were inventoried and analyzed. Multiple pipes and culverts at various sites were modeled separately. Approximately 13 sites were evaluated where two or more parallel pipes or culverts existed.

Data required for the hydraulic capacity analysis included material, dimensions, shape, slope, inlet type, and for culverts, the available head at the inlet. This information was gathered using three sources; the West Linn GIS data, the 1996 SWMM models, and field visits. The West Linn GIS data provided sizes and lengths for a majority of the pipes within the study area. The 1996 SWMM models used in earlier master planning efforts also provide sizes, lengths, and upstream/downstream invert elevations. Because a large amount of development has occurred in the study area since 1996, some of the SWMM data was incomplete or outdated. The fieldwork visits were generally to locations where the other two data sources provided conflicting data or where no data at all was available.

The stormwater collection and conveyance system for the West Linn study area is made up of pipes, culverts, ditches, and open channels. The pipes that run under and within the right-of-way of I-205 and Highway 43 are maintained by the ODOT. Clackamas County maintains pipes outside of the city limits but within the study area. The remaining system is operated and maintained by the City of West Linn. Table 4.8 shows the total length of stormwater conveyance owned by the various jurisdictions in the study area.

Table 4.8 Ownership of Stormwater Conveyance in the Study Area

Jurisdiction	Length of Facilities (feet)	Length of Facilities (miles)	Percent of Total
City of West Linn pipe	376,750	71.3	62
ODOT pipe	31,040	5.9	5
Open Channel (including ditches)	202,500	38.4	33
TOTALS	**610,290**	**115.6**	

4.8 HYDRAULIC DEFICIENCIES

Twenty-five year storm event criterion was used along with the hydraulic capacity estimates described earlier to determine what conveyances within the study area are deficient. The deficiency analysis was conducted on both existing and future land use conditions.

Appendix C presents the detailed results of the hydraulic deficiency analysis. The deficiency table found in the appendix includes the physical characteristics of the pipes and culverts along with their computed capacity for both the 25-year and the 100-year design flows. The table also tabulates the computed design flow for both existing and future conditions. And if deficient, it indicates whether that deficiency is already occurring now or is expected to occur in the future.

Approximately 96 pipes and/or culverts were found by the model to be deficient during the occurrence of the existing 25-year design event, which represents approximately 39% of the pipes and/or culverts examined. As the City continues to grow, approximately 11 more pipes and/or culverts are expected to become deficient during the occurrence of the future 25-year event which only represents approximately 4.5% more of the study area’s pipe and/or culverts. After further analysis City staff reduced the total number of deficient pipes and/or culverts to seventy-nine.

Figure 4.5 shows the stormwater conveyance system throughout the study area along with the locations of pipes and/or culverts that were determined to be deficient.

3.9 STREAM ALTERATION

Most stream corridors tend to be naturally unstable due to the local geology and topography and the action of water which together increase erosion. Erosion degrades water quality and increases the damage to property. Urbanization exacerbates erosion by increasing the volume and rate of runoff and reducing the vegetation that protects stream channels which could act to limit further erosion.

Channel Incision

The bankfull cross-sectional areas of rivers (*i.e.*, surface width times mean depth) is often correlated with stream flow and drainage area as an expression of channel size. Watershed research studies have confirmed that changes in bankfull channel dimensions correspond to changes in the magnitude and frequency of bankfull discharge, which has been found to occur after urbanization.

A common stream response to these increases in the frequency and a magnitude of bankfull discharges is channel down cutting or incision. This is evidenced in the field by stream channels with steep, almost vertical sides and visible erosion.

Recent research (Castro and Jackson, 2001) in channel altering behavior throughout the Pacific Northwest estimated that bankfull or channel forming flows for the Tualatin River Basin are essentially equal to the flow response from a 1.0 to 1.2-year return interval storm event. The 1.2-year return interval storm event for the West Linn study area is estimated to be equal to a 24-hour storm producing 1.9 inches of rain. Larger storms also cause changes to the stream channel but they occur more rarely and therefore do not have the same impact as the much more frequent 1.2-year event.

Within the West Linn study area, there are multiple locations of channel incision. The largest and most visible examples can be found in the lower reaches of the various watersheds discharging into the Willamette River downstream of the confluence with the Clackamas River. The upper stream reaches within the study also show some signs of downcutting, but more often than not the stream channel’s bed material is bedrock so no increase in incision is possible.

The existing condition HEC-HMS models were used to demonstrate how increased development impacts the channel forming flows. Twenty-one subbasins were selected to represent the natural conditions within the watershed. These subbasins all had less than 5% impervious coverage. A HEC-HMS model was run using a SCS Type 1A storm event with a total precipitation value of 1.9 inches (the 1.2-year event). The resulting peak flows from the basin provided an average unit peak flow of 0.07 cfs per acre for these twenty-one subbasin areas.

A comparison was made using similar results calculated for 23 subbasins with greater than 50% impervious coverage. The result was an average cfs/acre value of 0.28. This value is four times the unit peak flow for the natural conditions channel forming flows. The HEC-HMS models were used to determine the unit peak flow for all the entities used in the HEC-HMS model. The resulting average was 0.14 cfs/acre, which is twice the natural value.

Using the unit peak flow of 0.07 cfs/acre for natural subbasins, an analysis was conducted to determine what 24-hour precipitation value would produce the natural condition channel forming peak flow for urbanized subbasins. The HEC-HMS model was used with variable precipitation values until the discharge per acre value was approximately equal to the 0.07 cfs/acre, 24-hour value. The results suggest for the basins with over 50% effective impervious coverage, the equivalent 24-hour rainfall amount is 0.85 inches. For all other subbasins in the model, the equivalent value is 1.25 inches.

The hourly rainfall data for the Portland Airport was then analyzed to determine how many times the various 24-hour storm events have occurred during the 51-year period of record from 1949 through 2000. During this time period, 25 storms have been recorded with 24-hour total greater than 1.9 inches. One hundred thirty-five (135) storms with totals greater than 1.25 inches and 422 storms with over 0.85 inches were found during the 51-year period. Therefore, from the natural conditions to the highly developed conditions, the resulting channel forming flows occurs approximately 17 times more frequently (422/25= 17). Currently, the channel forming flows are occurring five times more frequently than one would expect for natural conditions (135/25 = 5.4).

The significant increase in the frequency of channel altering flows resulting from urbanization essentially increases the overall duration that these bankfull flows can act upon and erode the channel. Stormwater detention facilities designed to reduce peak flow can also significantly increase the duration of channel altering flows. This occurs because these facilities are designed to store floodwaters that would have overflowed downstream channels. After the peak inflow has past, the facility slowly releases the stored water. Most designs use the downstream bankfull discharge as the safe release rate, which ends up significantly increasing the time that these channel altering flows will occur.

The progression of downcutting or incision in streams is in an upstream direction. Incision traditionally starts at the lower ends of the stream where impacts from a changed hydrology are the greatest. The incision then migrates upstream until it hits a hard point in the channel or until it reaches an area in the stream where impacts have lessened to a level close to the natural conditions.

For channels experiencing downcutting, there are methods that can be used to halt the progression. For example, check dams are commonly used. Check dams are engineered structures placed across the streambed designed to replicate a hard point in the channel. They are usually placed at regular intervals along a stream channel. The placement of check dams also creates channel roughness, slowing down the flow velocity. This in turn creates a situation where sediment is deposited on the upstream side of the structure.

Properly designed and constructed channel modifications can provide a channel whose geometry, water handling capacity, and roughness will result in stable conditions that can eliminate incision. This usually involves a stable channel design that accommodates the stream energy from the natural conditions with the increased flow rates and frequencies due to urbanization. This method may require the purchase of large amounts of property to provide for the expanded channel geometry.

Another technique that can be used involves the attempt to recreate a more natural hydrologic response through the use of retention facilities. As opposed to a detention facility, a retention facility does not provide release of all of its storage volume. The retention basin incorporates infiltration so that the increase in runoff volume does not directly enter the natural stream system. The size of the retention facility depends on the attenuation of peak flows to values equal to the existing conditions for all flows under the 1.2-year event. The overall goal is to have the facility provide for a discharge hydrograph with equal peaks and durations. Unfortunately, a facility of this nature usually requires a considerable amount of relatively flat land and/or well-drained underlying soils, two conditions that do not generally exist throughout the West Linn study area.

4.10 REFERENCES

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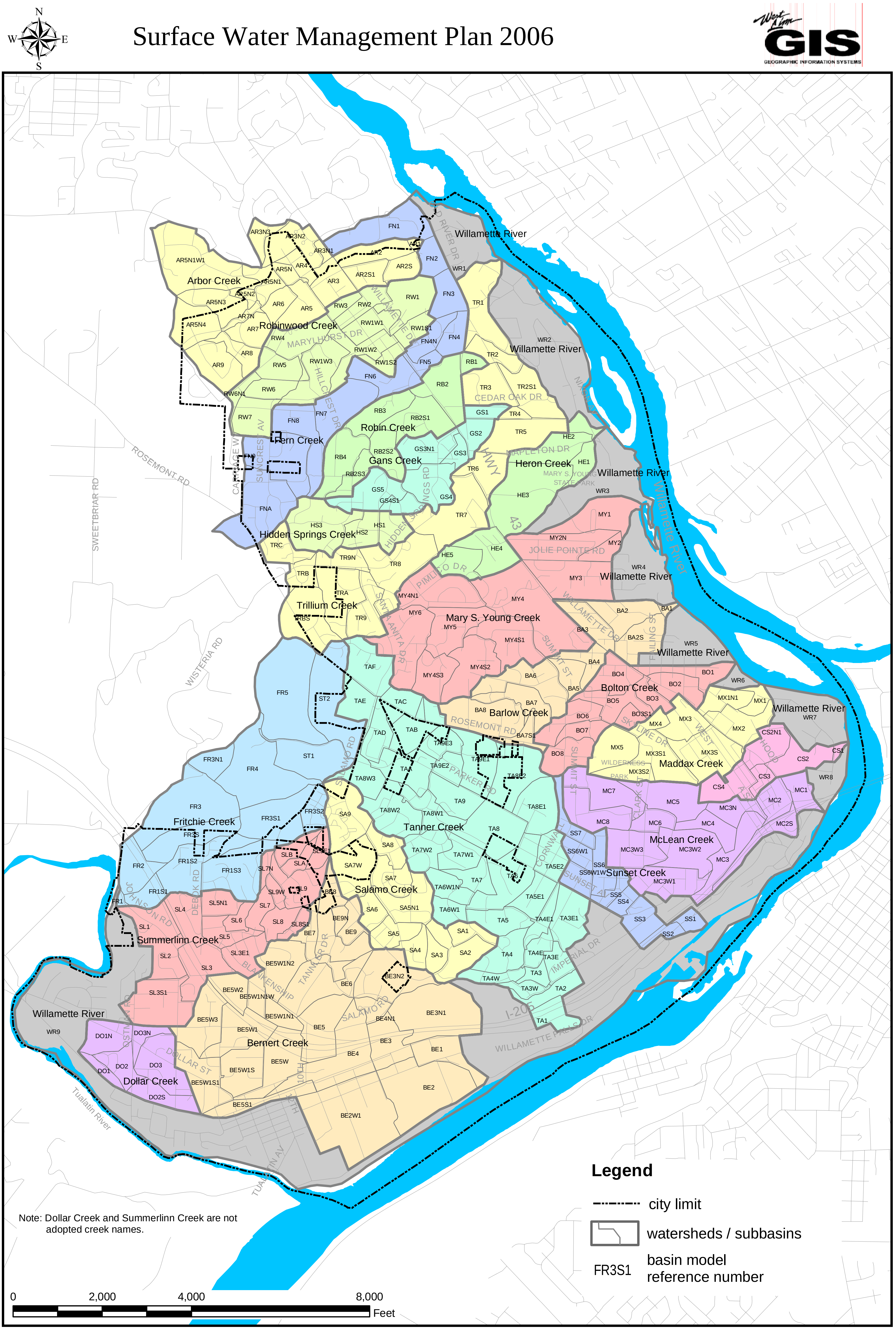
Surface Water Management Plan 2006



storm_mp2004\watershed_delineations.mxd | Lee | 9-14-06 (draft 8-03-04)

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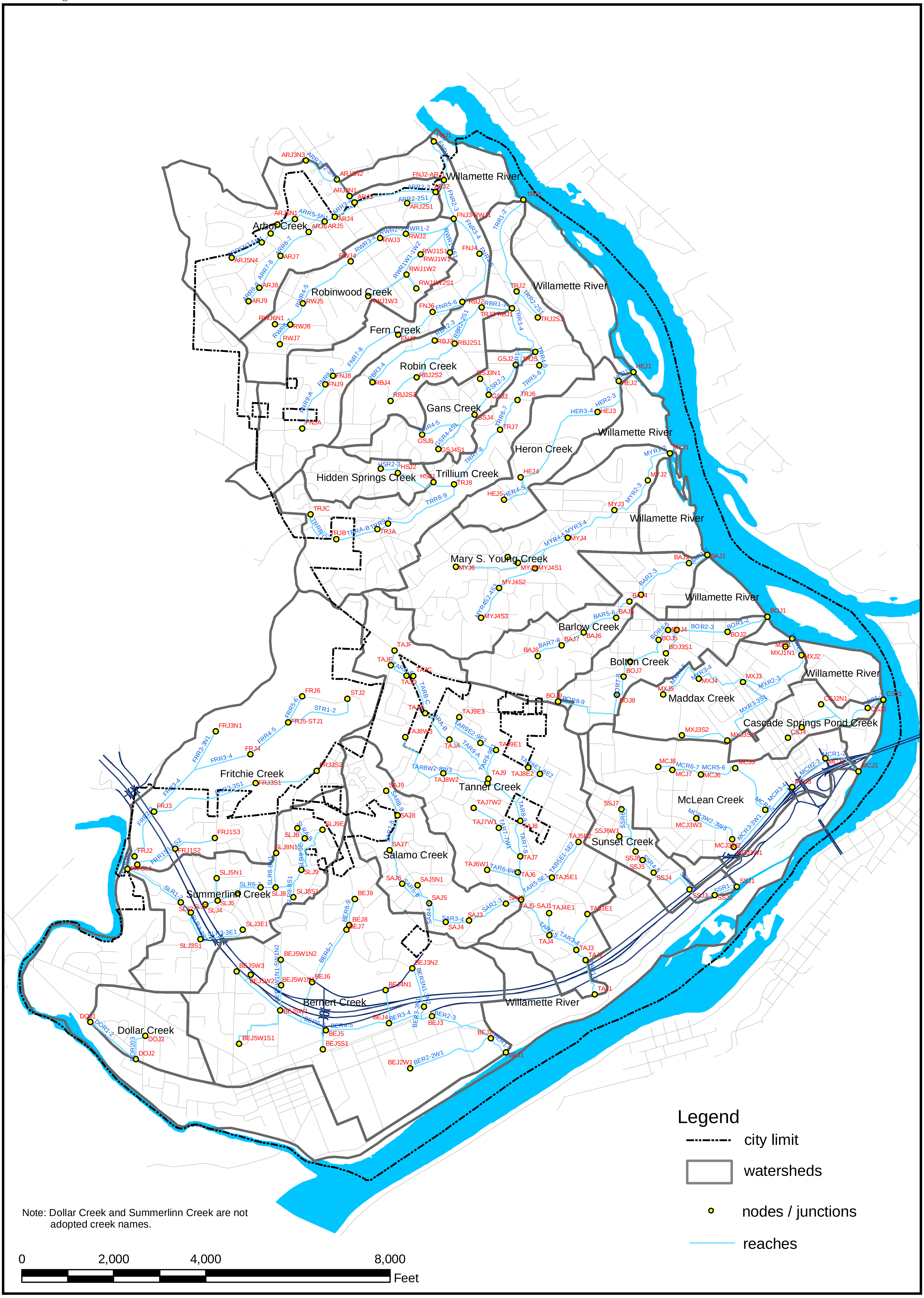
Taxlot Base Source: Clackamas County GIS

Figure 4.1 Watershed Delineations

Surface Water Management Plan 2006



storm_mp2004\reaches_junctions.mxd | Lee | 9-14-06 (draft 8-11-04)

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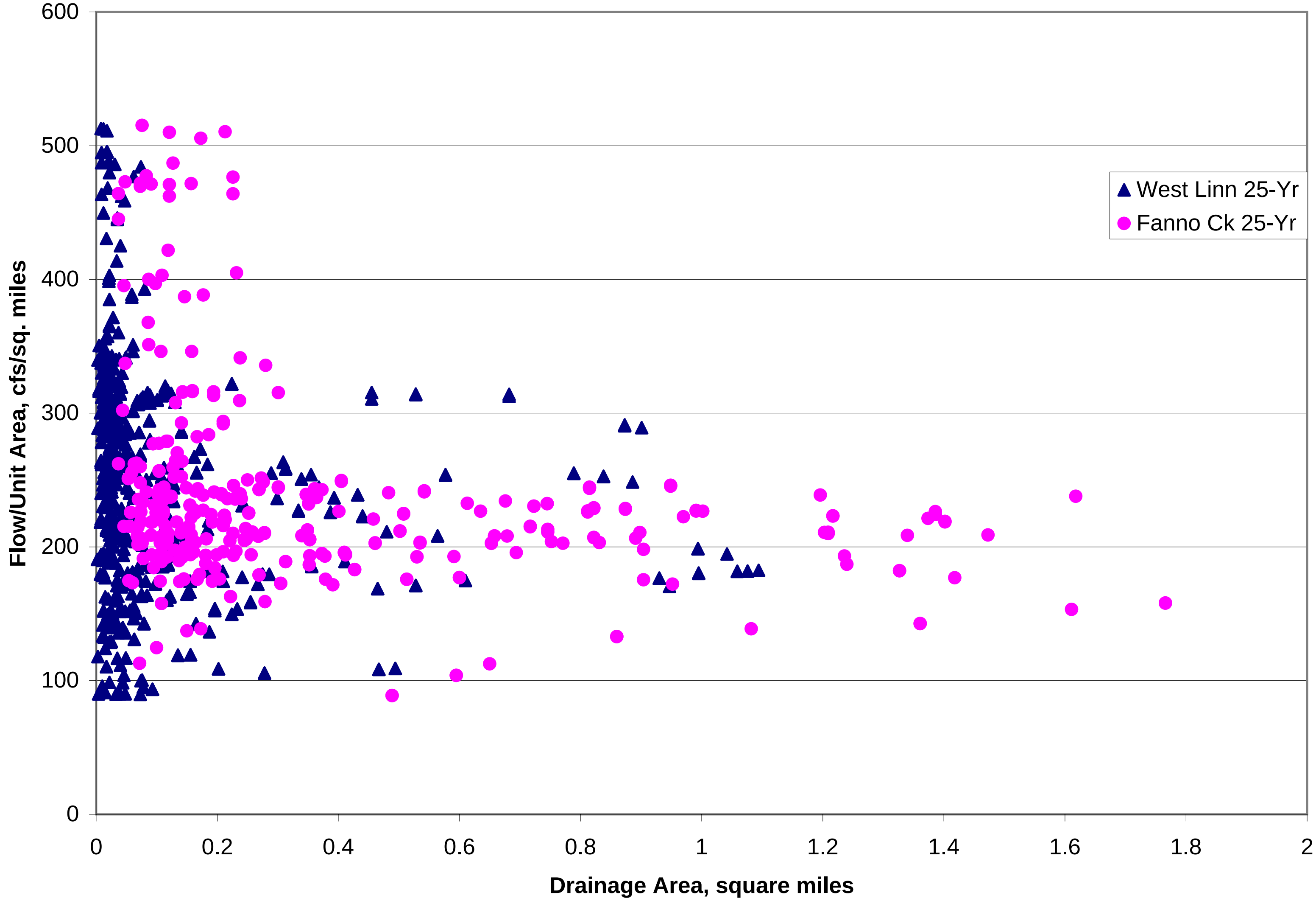
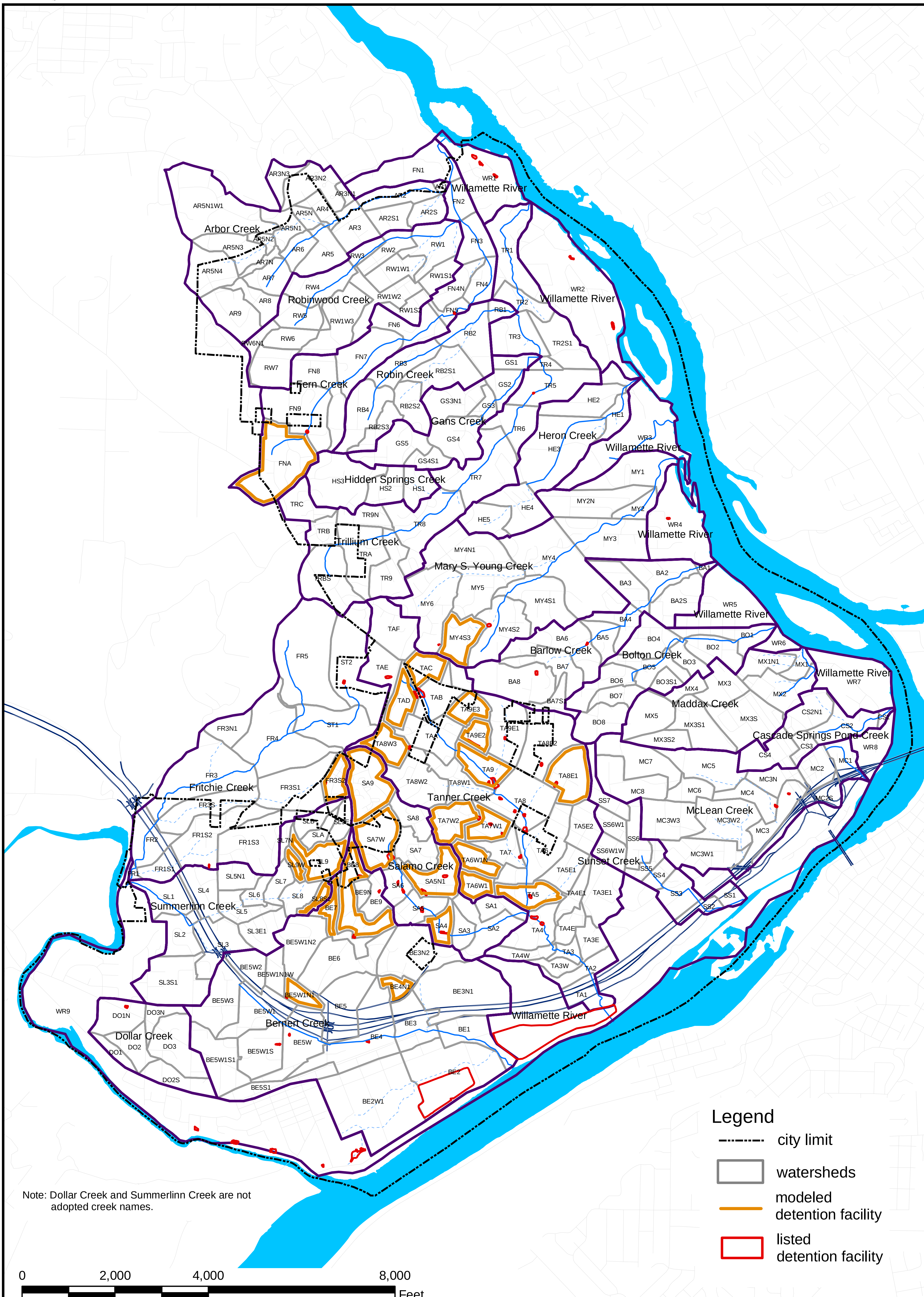
Figure 4.2 HEC-HMS Reaches and Junctions

Taxlot Base Source: Clackamas County GIS

Figure 4.3 25-Year Peak Flow Calibration Results for HEC-HMS Models



Surface Water Management Plan 2006

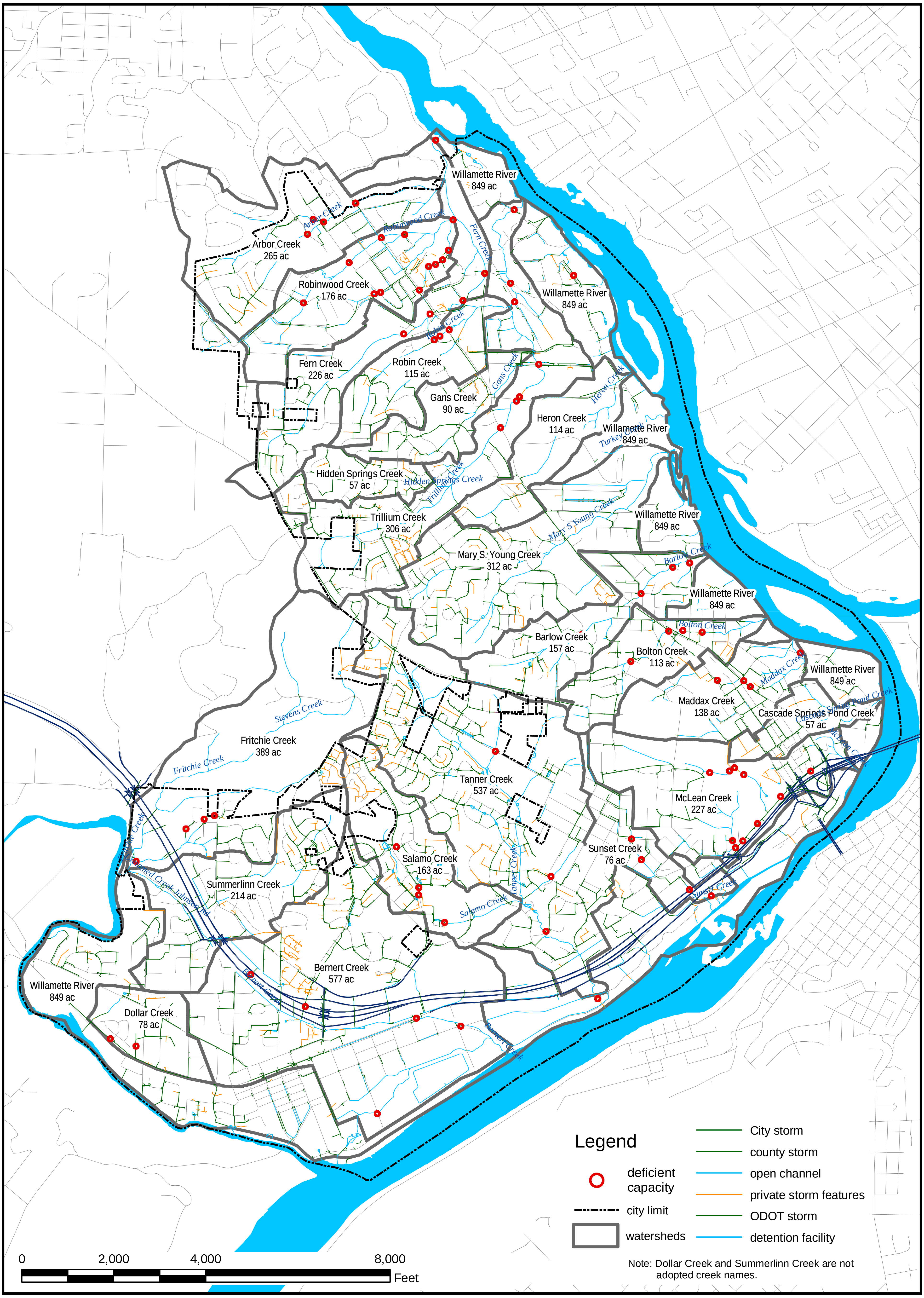


storm_mp2004\modeled_detention_facilities.mxd | Lee | 9-14-06 (draft 8-10-04)

Taxlot Base Source: Clackamas County GIS

Figure 4.4 Modeled Detention Facilities

Surface Water Management Plan 2006



storm_mp2004\deficient_capacity | Lee | 9-14-06 (draft 8-16-04)

This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Figure 4.5 Surface Water Collection System

Taxlot Base Source: Clackamas County GIS

Chapter 5

WATER QUALITY

As stated earlier in Chapter 2, one of the City's primary goals for surface water management is to reduce the discharge of pollutants in stormwater runoff to the maximum extent practicable (MEP). In an effort to achieve this goal, the City has already developed and implemented a NPDES stormwater management plan pursuant to Section 402 and 405 of the Federal Clean Water Act (CWA). The new West Linn Surface Water Management Plan is not designed to replace the existing NPDES plan or the new Stormwater Management Plan mandated by the City's new NPDES permit, but instead it must complement and augment these plans. The objectives of the water quality analysis are to:

- Evaluate the pollutant reduction benefits of existing maintenance practices
- Evaluate the pollutant reduction benefits of increased maintenance practices
- Identify other available water quality improvement techniques and evaluate their potential pollutant reduction benefits

This Chapter recommends best management practices for improvement of water quality

BEST MANAGEMENT TECHNIQUES

5.1 STRUCTURAL WATER QUALITY IMPROVEMENT TECHNIQUES

Numerous techniques are available for the improvement of water quality. The list has been limited to those techniques that affect the water quality of stormwater or surface water. In addition, the list has been separated into two general categories – structural and non-structural. The definition of each of these categories is somewhat subjective in that it is actually based on whether the implementation of the technique will require a capital expenditure from the City. If a capital expenditure is required by the City or another governmental agency, the technique is classified as structural. If not, it is classified as non-structural. The structural techniques are presented in Table 5.1.

The structural water quality improvement techniques shown in Table 5.1 have been divided into three broad categories. The first two categories (*i.e.*, natural resources enhancements and regional water quality projects) deal with the stream and its associated riparian corridor. The third category (retrofit urban storm systems) deals with techniques applied to the storm drainage systems that are tributary to the streams themselves.

Table 5.1 Structural Water Quality Improvement Techniques

Natural Resources Enhancements
- Tree Planting
- Vegetative Buffers
- Streambank Stabilization
- In-Stream Stabilization
- Increase Floodplain Function

Regional Water Quality Projects
- Sedimentation/Detention
- Bio-Filtration/Swales
- Biological Uptake/Created Wetlands

Retrofit Urban Storm Systems (existing development)
- Traditional Sedimentation Devices
  - *Water Quality Inlets*
  - *Pollution Control Manholes*
- Enhanced Sedimentation Devices
  - *STORMCEPTOR®*
  - *VORTECHS®*
  - *DOWNSTREAM DEFENDER®*
- Bio-Swales
- Media Filtration Devices
  - *Storm Filter ®*
  - *Peat-Sand Filter*
- Reduce Effective Impervious Surfaces (to infiltration)
  - *Roof Drain Disconnect*
  - *Porous Pavement/Pavers*

Natural Resource Enhancements
Natural resource enhancements are water quality improvement techniques that are applied along or within the stream channel itself. These techniques are used to reduce sediment and associated pollutants that originate near or in the stream channel itself. Given the steepness of the stream channels throughout the West Linn study area, many of these techniques can be used to address erosion and scour problems encountered and described later in Chapter 6.

Tree Planting involves the planting of trees and other woody vegetation along the stream itself to provide shading for temperature reduction and habitat for birds and other wildlife.

Vegetative Buffers involve the establishment of an open pervious area or buffer along the stream that is vegetated to provide for filtering of overland flow moving to the stream and habitat for birds and other wildlife.

Streambank Stabilization usually involves bio-engineering techniques that utilize natural vegetation and live stakings arranged in a structurally sound pattern that can help stabilize eroding streambanks, lower suspended sediment concentrations and provide for better fish habitat.

In-Stream Stabilization usually involves the placement of woody debris to encourage in-stream sedimentation that can help stabilize a degrading (*i.e.*, downcutting channel) to reduce erosion, lower suspended sediment concentrations and provide for better fish habitat.

Increase Floodplain Function technique is essentially identical to the "increase in-stream storage" technique discussed under flood reduction (see Section 7.2). The desired result is to increase the frequency and duration of a stream's use of its floodplain, which provides water quality benefits through the trapping of sediments on the stream's overbanks or floodplains. This technique usually requires a higher level of engineering and usually involves in-stream control structures. And as noted later in the "in-stream storage" discussion, the relatively steep stream channels located throughout the West Linn study area generally will likely render the "increase floodplain function" technique for water quality improvement as infeasible.

Regional Water Quality Projects
The second set of techniques labeled regional water quality projects has been separated from natural resources enhancements to illustrate the fact that a much higher level of engineering and hydraulic design is usually required for these type of projects. These projects are regional in nature, which means they are designed to treat stormwater from a large area and not simply that from a single parcel or site. Although these projects are usually located on a land parcel that the stream traverses, they generally require greater land area than that required for the natural resources enhancements described earlier. These projects usually involve some land modifications through grading to provide the various water quality improvement processes that have been listed. It is interesting to note that many of the natural resources enhancement techniques described earlier could be and are usually used in the development of regional water quality projects. However, the generally steep topography throughout the West Linn study area severely limits the use of these techniques.

Sedimentation/Detention usually involves the construction of a wet pond, which has lots of open water and a significant amount of dead storage volume (*i.e.,* water stored in the pond below the minimum outlet elevation) that encourages the deposition of sediments entering the facility. The pond's potentially negative impact on stream temperature can be somewhat reversed by the use of an extended dry design such that during a wet weather event a wet pond with considerable dead storage volume is created. However, this dead storage volume is gradually drained between storm events by the use of weep holes in control structures or infiltration trenches.

Bio-filtration/Swales located in regional facilities usually involve the construction of large, well vegetated and primarily grassed areas that are designed to provide for shallow, slow stormwater flow that will maximize potential infiltration and sediment filtration.

Biological Uptake/Created Wetlands usually involved the construction of a man-made wetland, which requires hydric soil conditions and good hydrologic control. The wetland vegetation provides the desired biological update of various pollutants but primarily the nutrients. Other processes such as sediment filtration, sedimentation and infiltration also occur in a created wetland facility. However, good design requires the upstream removal of excessive sediments, metals and toxics through the use of a sedimentation pond or another sedimentation device upstream of the wetland.

Retrofit Urban Storm Systems
The third set of structural techniques involves the potential retrofit of key portions of the urban storm system. Existing storm sewer systems provide the conduit for the direct transport to the stream of contaminated material that accumulates on directly connected paved areas or impervious areas. Retrofit is the modification of these systems to intercept or passively treat the contaminated stormwater before it reaches the stream or creek. The processes used are similar to those listed under regional water quality

projects and include sedimentation, bio-filtration and filtration. Urban storm system retrofits are usually very expensive since they generally involve highly engineered structures that must be fit into an urbanized area and often must be installed underground. These facilities need to be maintained or cleaned on a frequent basis, which increase their overall cost. In a retrofit situation, it is a common practice to design a high flow bypass such that all storms up to a specified water quality storm receives treatment and flows greater than the water quality design flow are bypassed. All of these retrofit techniques could be used to reduce stormwater pollutants throughout the West Linn study area.

Traditional Sedimentation Devices involve passive sedimentation devices such as sediment trapping water quality inlets and sedimentation or pollution control manholes. All of these devices rely on the use of an enclosed sump or sediment storage area below the outlet pipe that accumulates sediment through a natural sedimentation process.

Enhanced Sedimentation Devices are specialty devices that are generally located underground and are designed to capture more and finer sediment than the traditional devices described above.

Bio-swales are grassy swales, which in the context of urban retrofit are usually designed at the outfall of a storm system to filter sediment and other pollutants from stormwater before it enters the stream.

Enhanced Filtration Devices are specialty stormwater filtration devices that can provide a high level of sediment and associated pollutant reduction through the use of various filtration media such as composted leaves or the combination of sand and peat

Reduce Effective Impervious Surfaces usually involves the disconnection of roof drains that are directly connected to the storm system. Other disconnection techniques involve the use of porous pavement and/or porous pavers to replace existing directly connected impervious surface. Although this technique is considered a challenge in a retrofit situation, the water quality benefits in the form of decreased pollutant and heat inflow into the stream will be significant.

Potential Water Quality Benefits
Needless to say, very few of the water quality techniques presented in Table 5.1 easily lend themselves to accurate quantification. In an attempt to provide some quantification to the potential effectiveness of these structural water quality techniques, Table 5.2 has been prepared. Keep in mind that the ratings in Table 5.2 are quite subjective in nature and apply only to the context in which the technique was presented and described.

5.2 NON-STRUCTURAL WATER QUALITY IMPROVEMENT TECHNIQUES

As discussed in Section 5.1, non-structural water quality improvement techniques are actions or activities that do not require a governmental expenditure of capital dollars to create physical improvements to the landscape or surface water collection system. The street and catchbasin cleaning activities discussed in Section 5.4 would be classified as non-structural. Public involvement and public education are classic examples of non-structural water quality improvement techniques. City and other governmental regulations, ordinances and permit programs are also examples of non-structural water quality improvement techniques. It is interesting to note that although some of these regulations can require others to expend capital dollars to create physical improvements to the landscape or surface water collection system, they are still considered to be non-structural water quality improvement techniques. A good example is the City’s current regulation that requires permanent stormwater control facilities for all new development. The regulation results in capital expenditures by land developers to construct facilities, but the requirement itself is still considered to be a non-structural water quality improvement technique.

In fact, most of the actions and activities being implemented as part of the City's current NPDES plan would be considered non-structural water quality management techniques.

Table 5.2 Potential Benefits of Structural Water Quality Improvement Techniques

Techniques	Water Quality Problems Addressed								Other Benefits	
	Higher Temp	Upland Erosion	Instream Erosion	Sediment Deposition	Higher Nutrients	Higher Metals	Higher Bacteria	Higher Oxygen Demand	Reduce Flood	Improve Habitat
Natural Resources Enhancement										
Tree Planting	H	N/A	L	N/A	N/A	N/A	N/A	N/A	N/A	M
Vegetative Buffers	M	N/A	M	L	L	L	L	L	L	M
Streambank Stabilization	H	N/A	H	L	M	L	L	L	L	M
In-Stream Stabilization	L	N/A	H	M	M	L	L	L	L	H
Increase Floodplain Function	N/A	N/A	N/A	H	L	L	L	L	M	L
Regional Water Quality Projects										
Sedimentation/Detention	L	N/A	N/A	H	L	M	L	L	H	L
Bio-Filtration/Swales	M	N/A	N/A	M	M	M	L	L	M	L
Created Wetlands	L	N/A	N/A	M	H	M	H	M	M	H
Retrofit Urban Storm Systems										
Traditional Sedimentation Devices	N/A	M	N/A	M	L	M	L	L	N/A	N/A
Enhanced Sedimentation Devices	N/A	H	N/A	H	L	H	L	L	N/A	N/A
Bio-Swales	L	L	N/A	L	L	M	L	L	L	L
Media Filtration Devices	N/A	H	N/A	H	M	H	H	M	N/A	N/A
Reduce Impervious Surface	L	L	N/A	N/A	N/A	N/A	N/A	N/A	L	N/A

H – High M – Medium L – Low N/A – Not Applicable

NPDES Stormwater Management Plan

The National Pollution Discharge Elimination System (NPDES) program is a congressionally mandated program under the Clean Water Act. The program is a comprehensive two-phased national program for addressing the non-agricultural sources of stormwater discharges that adversely affect water quality. The program is implemented locally through the Oregon Department of Environmental Quality (DEQ). DEQ issues permits to applicable entities that participate in and/or oversee activities, which are recognized as potential sources of pollutants. Municipal Separate Storm Sewers Systems (MS4), industrial activities and construction activities all potentially require an NPDES permit.

The City of West Linn obtained a permit under Phase 1 of the NPDES program in 1995. The City operates under a MS4 system, which means that all stormwater is collected and conveyed in a storm sewer system separate from the sanitary sewer system. Under Phase 1 of the federal program only MS4 systems serving a population of 100,000 or larger were required to obtain a permit. Although the City of West Linn was not subject to Phase 1 requirements, the City took a progressive stance towards water quality and chose to comply with the NPDES permit as a co-applicant with Clackamas County.

As part of the permit the City has developed a Stormwater Management Plan that outlines Best Management Practices (BMPs) that the City will implement to improve and conserve water quality, as well as prevent harmful pollutants from contaminating stormwater runoff and entering the MS4. The City's current NPDES program includes the identification of major stormwater outfalls; the detection and elimination of non-stormwater discharges to the MS4; the reduction of pollutants in runoff from industrial, commercial and residential areas; the control of stormwater discharges from new development and redevelopment; and the regular maintenance of the public stormwater collection/treatments systems.

Compliance is essentially achieved by implementing an approved Stormwater Management Plan. Each permit holder is required to report annually the procedures, tasks and best management practices achieved that benefit water quality. The City of West Linn's 2001-2002 Annual NPDES Report submitted in August 2002, documents the actions and activities the City completed in fiscal year 2001-2002 in implementing the current plan. As mentioned above, the NPDES plan is quite extensive and effectively implements a large number of non-structural actions or activities designed to reduce pollutant discharges into the City's stormwater. Please refer to the NPDES plan for more detail on these activities. The intent of the Surface Water Management Plan is to identify what additional actions or activities, if any, could be taken to improve water quality throughout the City of West Linn.

Street and Catchbasin Cleaning of Private Properties

Currently the City does not clean streets, parking lots or sediment trapping catchbasins located on private properties. As a general rule, most of the private properties are both multi-family residential and commercial and are estimated to have much higher pollutant loads when compared to single-family residential. Sediment trapping catchbasins were found in seven of the eight multi-family and commercial areas.

The City should consider passing an ordinance that requires the annual inspection and cleaning of catchbasins located on private property. The ordinance could require that the property owner or manager certify every year through a cleaning contractor that the inspections and cleanings have been completed. Additionally, the City should consider passing an ordinance that requires street or parking lot cleaning on some periodic basis (e.g. six months). More frequent sweeping of private curbed streets and parking lots should be encouraged.

Better Site Design (Low Impact Development)

Development alters the surface of the land by replacing natural cover with rooftops, roads, parking lots, and sidewalks. These hard surfaces are impermeable to rainfall and are collectively known as impervious cover.

Recent watershed research has shown that impervious cover has a profound and often irreversible impact on the quality of our nation's aquatic resources. More than thirty different scientific studies have documented that stream, lake and wetland quality declines sharply when impervious cover in upstream watersheds exceed 10 percent. The strong influence of impervious cover on aquatic systems presents a major challenge to communities interested in sustainable development. We cannot protect the quality of the local stream environments unless we manage impervious cover and impervious cover can be managed by a coordinated approach through the City codes governing development.

The Sustainable West Linn Strategic Plan of July 2006 contained many considerations for the development process. Those pertaining to surface water management as follows:

- Retain and use rainwater on site,
- Storm drainage system that uses natural open drainage ways,
- Management of storm water using low impact development with soft engineering approaches including bioswales, porous pavements, and green streets.
- Disconnection of rain drains and using onsite drainage and plants to keep most of the storm water on originating property.

The current City policies and practices fully support those concerns expressed in the Sustainable West Linn Strategic Plan of July 2006.

The current City policies and practices are also fully compliant with goals 5 and 6 of the City of West Linn Comprehensive plan. Specifics of those goals relating to surface water management include maintaining water quality, preventing erosion, restoration of existing stream corridors, removal of invasive species and restoration of natural vegetation, improving stormwater detention and treatment standards, reducing storm runoff, maintaining open channels and encourage re-opening of culverted channels.

The Citizens Advisory Committee reviewed a publication entitled, "Better Site Design: A Handbook for Changing Development Rules in Your Community", August 1998 (Center for Watershed Protection, 1998). (Go to www.cwp.org for more information.) These principles reduce impervious cover, conserve natural areas and prevent stormwater pollution from new development, while at the same time maintaining a high quality of life within the community. Most of the items identified by the committee for changes in policy and practices do not deal with surface water management but related instead to changes in the Community codes under the purview of the Planning Department and Building DivisionDevelopment Code or Building Code and thus are not included in this plan. Those items specifically relating to surface water management are contained in Section 9 Recommendations.

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Chapter 6

NATURAL RESOURCES EVALUATION

As stated earlier in Chapter 2, one of the City's primary goals for stormwater management is to protect and maintain the natural functions and values of the area's surface waters. In an effort to preserve resources and avoid duplication, the PWR team was not scoped to conduct extensive fieldwork as part of the team's natural resources evaluation. Instead, Fishman Environmental Services (FES), the natural resources consultant on the PWR team, was instructed by the City to rely heavily on the documentation of the field work conducted by WinterBrook Planning as part of their Goal 5 related riparian corridor assessment work being completed for the City under a separate contract. Goal 5 is the Natural Resources, Scenic and Historic Areas, and Open Space planning goal included in Oregon's Comprehensive Land Use Planning framework which was briefly described in Chapter 2.

Goal 5 administrative rules require local governments to inventory and evaluate Goal 5 resources and develop land use programs that conserve and protect significant Goal 5 resources. These resources are:

- riparian corridors, including water and riparian areas and fish habitats
- wetlands
- wildlife habitat

The focal point of the limited fieldwork conducted by FES in October 2002 as part of the surface water management plan project was to identify specific enhancement or restoration opportunities in the study area as part of the presentation made to the City Council work session on the stormwater planning process that occurred on November 26, 2002. Another source of information available to FES as part of their evaluation work was a fish passage related culvert inventory conducted by the City of West Linn staff.

6.1 FISH SAFE CULVERT INVENTORY

The Fish Safe Culvert Inventory completed by the City staff in March 2002 identified and prioritized culverts that were deemed impassible for migrating species in the streams throughout the City that Oregon Fish and Wildlife (ODFW) determined to possibly be fish bearing. The streams were split into two sets. Those identified by ODFW as possible fish bearing that were within the City limits and tributary to the Willamette and Tualatin Rivers, respectively. They were:

Willamette River Tributaries

- Arbor Creek
- Trillium Creek
- Tanner Creek

Tualatin River Tributaries

- Fritchie Creek

- Unnamed Creek (renamed Summerlinn Creek for the Surface Water Management Plan)

Private culverts were not inventoried although their locations were identified. The fieldwork discovered a natural barrier (*i.e.,* waterfall) at the outlet of Tanner Creek that would prevent any possible fish migration. As a result, culverts in the Tanner Creek watershed were excluded from the study.

Nineteen culverts were inventoried. The City's report on Fish Safe Culvert Inventory contains a detailed description of the ratings that were used. The recommended order of priority for repair or replacement has been reproduced below in Tables 6.1 and 6.2. Note that the culvert IDs from the hydraulic deficiency assessments in Chapter 3 are also tabulated.

Table 6.1 Replacement or Repair Priority for Impassable Culverts Inventoried in the Willamette River Tributaries

Priority Number	West Linn Culvert Name	PWR ID Information
1	Calaroga Rd.	635
2	Old River Road	632
3	Willamette Falls Drive (W of Mapleton)	618
4	Elmran Ave.	634
5	Mapleton Dr.	620
6	Willamette Falls Drive (N of Arbor)	657
7	Mapleton Dr. (private)	494
8	Kenthorpe Way	626
9	Cedar Oak	627
10	Willamette Falls Drive (Walling Circle)	631
11	Trillium Dr.	633

Table 6.2 Replacement or Repair Priority for Impassable Culverts Inventoried in the Tualatin River Tributaries

Priority Number	West Linn Culvert Name	PWR ID Information
1	Meadowview Ct.	517
2	N side of Johnson Road	519
3	Ryan Court	516
4	Johnson Road at 19^{th}	518
5	Blankenship	436
6	Johnson Road (near 23350)	508
7	19^{th} Street	435

The final recommendations of the City's Fish Safe Culvert Inventory project is tocomplete more culvert evaluations during different seasons to get a more complete picture of stream conditions throughout the year

6.2 NATURAL RESOURCES ASSESSMENT

The following natural resources assessment or evaluation was prepared by FES in November 2002. The basis of the information compiled was WinterBrook Planning's Goal 5 Riparian Corridor Summary Sheets and their Wildlife Habitat Assessment Summary Sheets dated July 2002. Additional field information gathered on October 29, 2002 by FES staff was also noted where appropriate.

The basin-by-basin assessments are included as Appendix F include basic recommendations to remove invasive species, restore native plants, and enhance fish habitat where appropriate. This is approach is in agreement with the Sustainable West Linn Strategic Plan of July 2006 which recommended control (removal or prevention) of invasive species on properties (public and private) throughout the City. These recommendations actually represent the natural resources solution options that are considered available in each waterway. The assessment is presented from north to south by larger watershed, major basin (*i.e.,* study watersheds) and stream locations.

Chapter 7

FLOOD MANAGEMENT PLAN

Flood management seeks to develop a unified land drainage and flood control program. Such a program can reduce future flooding while systematically eliminating annual flooding through implementing capital improvements and developing policies that preserve natural drainageways and floodplains. Existing problems can be mitigated by applying the proper combination of nonstructural and structural measures. Nonstructural components recognize the natural drainage system and seek to preserve these features. Structural components change floodwater distribution by conveying it, storing it or a combination of these strategies.

Developing the flood management plan involves a four-step process:

1. Establish the program goals

2. Identify the primary techniques of implementing flood management.

3. Apply these techniques to control flood impacts, comply with the adopted design criteria and develop a management plan for each major drainage basin.

4. Document unit cost data for developing CIP construction costs.

7.1 FLOOD MANAGEMENT PLANNING GOALS

The planning goals for a flood management program should be consistent with the City of West Linn's Comprehensive Plan goals and the community objectives for stormwater management.

The City's stated goal for storm drainage facilities planning (*i.e.*, Goal 11 of Comprehensive Plan) is to create and maintain a drainage management system that manages the amount and rate of surface water runoff, eliminates interbasin transfers of storm drainage, minimizes property damage from runoff, and controls pollution entering receiving stream. Pollution control was previously addressed in Chapter 5.

The community objectives related to the water quantity aspects of stormwater management are:

- Integrate both drainage control and water quality needs in the City's watersheds that also emphasize the use of natural systems.

- Coordinate and/or consolidate the City's resources to focus efforts on flood control and on the reduction of pollutants associated with stormwater runoff.

- Implement funding mechanisms that equitably allocate costs to those that benefit from stormwater management.

- Ensure that expenditures of program elements are commensurate with their benefits.

7.2 FLOOD MANAGEMENT TECHNIQUES

Once it is determined that a flood risk is unacceptable, there are several techniques available to mitigate the risk to a more acceptable level. These include:

- Increase conveyance or capacity of pipes, culverts and open channels to carry peak flood flows.
- Increase detention storage both locally and regionally to delay or reduce peak flood flows downstream of the storage location.
- Increase the in-stream storage available or change the threshold stream flow at which the available floodplain storage starts to be utilized.
- Divert high stream flows away from or around a flooding problem to a place downstream where greater capacity exists.
- Acquire properties or conservation easements in flood prone areas, as they become available.
- Reduce and/or disconnect from the storm sewer system the impervious cover of the watershed.

Increase Conveyance

This technique focuses on increasing the capacity of the downstream conveyance system to carry the flood flows more efficiently, thereby reducing the upstream flood elevations. Conveyance improvements should be designed taking full advantage of the natural system, without impacting property, streams, wetlands, or receiving water. However, when the natural system is inadequate because site-specific factors limit its utility, it may be necessary to construct structural conveyance devices.

These improvements involve either replacing existing culverts and storm drain systems with larger facilities, removing debris or certain types of vegetation, or lining the channel with armoring rock or other materials to reduce channel friction and erosion.

These do not generally improve water quality except, perhaps, by reducing erosion. Many structural facilities increase the concentration of stormwater pollutants by directly discharging to streams and bypassing natural filtration processes. Moreover, in some instances these can increase downstream flood peaks. However, structural conveyance remains one of the most effective (and often the only effective) means of mitigating flood risk.

Detention

Detention – either local (*i.e.,* on-site) or regional – can mitigate downstream flood risks by reducing the flows enough that the resulting water surface near the at-risk site drops to an acceptable range. Detention works in one of two ways. In-line detention constricts the channel (usually with an undersized culvert) in order to back up floodwaters into enlarged floodplain storage areas. Off-line detention uses storage located immediately adjacent to the stream. The storage remains dry during low flows when downstream capacity exists, but it is usually designed to start filling as the channel begins to exceed its capacity.

In general, off-line detention is preferred for regional detention because it makes more efficient use out of a given storage volume, since little storage is used when downstream capacity exists. Moreover, it does not require obstructing the natural channel as with in-line detention. And finally, the storage areas offer more potential for secondary uses since they only flood when the creek is at or near flood stage, whereas in-line detention floods much more frequently.

However, effective detention of either type must be carefully designed. Detention can greatly increase the duration of channel altering flows as discussed in Chapter 4. Thus, in instances where erosive channel altering flow is a concern (particularly when detention is associated with new development), it is appropriate to “over detain” to match a developed, post-project flow to an existing flow of a smaller event (*e.g.,* 10-year developed reduced to a 1.2-year).

Since in-line facilities require a flow control within the main channel, they are seldom practical along the main streams, and are best confined to local sites. Along main channels where in-stream controls are neither practical nor desirable, only the possibility of off-line detention is considered. However, off-line detention requires storage areas that remain dry until the creek nears flood stage, and therefore seldom coexists well with natural resources or water quality projects that seek to lower the floodplain so that they become inundated more frequently.

Extensive storage volumes and large, flat sites near major streams are required in order to reduce downstream flows enough for an otherwise deficient structure to become acceptable without further replacement, since this normally needs a large drop in flow. Moreover, even more flow reduction and even larger detention volumes are needed to mitigate flood risk along a downstream channel (*e.g.,* at a building) that is not locally constricted by an undersized culvert or bridge. As a result, regional detention is often only an effective flood mitigation technique when large off-creek areas are available which can be flooded.

In the West Linn study area, the generally steep topography severely limits the use of off-line detention. The few sites that exist are located close to the confluences with the Willamette and Tualatin Rivers and as a result would provide flow reduction benefits for relatively short reaches of the streams that they would be designed to serve. However, the analysis of existing local and regional in-line stormwater detention facilities showed that these types of installations can be somewhat effective at reducing peak flows from on-going development activities.

Increase In-Stream Storage

In-stream storage is similar to detention in that additional volume is provided to delay and therefore reduce peak flood flows. However, the storage is both in-line (and thus less efficient) and without any restriction or control on outflows. Thus, considerable benefits may accrue to natural resources or habitat, and the inherent provision of a protective buffer around the stream may improve in-stream water quality, but any significant flood reductions would require such extensive overbank flooding as to make this option prohibitively expensive.

The most desirable way to implement this technique is by excavating the adjacent floodplain without using check dams or other restricting structures that essentially raise the streambed, encourage channel siltation, and decrease the ultimate capacity of the stream channel. Once again, however, the relatively steep stream channels located throughout the West Linn study area generally render the use of increased in-stream storage for flow reduction as infeasible.

Divert or Bypass High Flows

This technique simply augments the existing system with an additional path for high flows that bypasses the downstream flood risk. This can be as small as adding a second culvert or bridge opening alongside the existing one (which is retained), or as large as constructing a second high flow channel outside of the existing corridor. In the former case, this technique would essentially be identical to increasing conveyance described earlier. Diversions can provide secondary benefits by conveying flows to nearby wetlands or detention areas.

The flood reduction from diverting high flows into bypass channels is very site specific and depends upon the downstream water surface (where the diversion rejoins the main stream), the elevation difference along the diversion channel, and the geometry of the main stream channel. To provide much benefit, the diversion must bypass a local feature that significantly retards flow. Restrictions may include a constricted stream section, extensive meanders, or in-stream structures (including buildings).

Without such a restriction in the channel, it may be very difficult to significantly reduce the upstream water surface elevation because it may remain dependent on the downstream water surface, which is unaffected by the diversion. It is easy to significantly under-design diversion channels by forgetting that the upstream flood depth depends not only on downstream flow and slope, but also on downstream depth. In general, the proper design of a diversion channel often requires the use of a detailed backwater hydraulic model such as HEC-RAS and can yield a channel size that significantly exceeds that of the main channel. No major open or closed diversions were evaluated as part of this project. They tend to be costly and can adversely affect the main stream channel.

In general, diversion is most useful when it means the simple addition of extra culverts or bridge openings at an existing, constricted location. This can result in a lower project cost than upsizing to a single, much larger culvert or bridge. However, this is not always a possibility, and in any case, adding culverts or bridge openings was treated as a conveyance improvement in this report.

Acquire Properties

In many instances, it is considerably more cost effective to purchase flood-prone properties than to expend considerably more to mitigate the flood risk by increased capacity or detention. This is particularly the case when only a few isolated buildings flood most often, and more than their worth would be needed to mitigate their flood risk. In addition, mitigating flood risk to a few high-risk sites usually means that many more at-risk structures remain unprotected because there are limited mitigation opportunities and resources.

It is often in the public interest to gradually acquire land and property within the floodplain. Public ownership of the floodplain would allow the demolition of existing structures and the setting aside of the land for flood conveyance purposes. It would also allow a more comprehensive restoration of wildlife habitat within the riparian corridor.

However, many areas limit these acquisitions to instances where there is a willing seller of floodplain property. Properties most vulnerable to flooding, that is, those within the 10-year floodplain, should be given the highest priority for acquisition. In any case, these properties can be used for a number of additional purposes where flood risk is more tolerable including open space, active or passive recreation, or natural resources enhancement. Current thinking in engineering and planning circles is that construction of homes, apartments and businesses within the 100-year floodplain should be avoided.

The currently delineated 100-year floodplains in the West Linn study area (see Figure 3.7) are associated with both the Willamette and Tualatin Rivers. It is unknown how many homes or businesses are within the existing floodplain but it is not believed to be very many. As a result, no specific recommendations will be made as part of this plan to acquire any homes or businesses within these floodplains.

Reduce Effective Impervious Area

Reducing effective impervious area (EIA) is defined as disconnecting impervious surfaces such as sidewalks, rooftops, parking areas, and streets from the drainage system so that runoff does not flow directly to storm sewer systems that outfall to streams. Reducing the amount of EIA that flows into the stormwater system allows the watershed's hydrologic cycle to respond in a manner that more closely reflects pre-disturbed conditions since infiltration is generally increased through the use of rain gardens or porous pavement for example (though it does not restore such condition). EIA reduction can occur as part of new development, redevelopment, or be part of a retrofit design. The level of benefit is determined by how well the practices minimize runoff in small to mid size storm events.

The relationship between imperviousness and runoff may be widely understood, but it is not fully appreciated. For example, the total runoff volume from a one-acre parking lot could easily be 10 to 16 times greater than from an undeveloped meadow of the same area. Imperviousness is a very useful indicator with which to measure the impacts of development on aquatic systems. Recent research has shown that negative impacts to aquatic systems occur at relatively low level of effective imperviousness around 10 to 20 percent.

The two primary components of imperviousness are rooftops under which we live, work and shop, and the transport system (*i.e.*, roads, driveways, parking lots, pathways and sidewalks) that we use to get from one roof to another. As it happens, the transport component often exceeds the rooftop component in terms of total impervious surface.

Traditional zoning has strongly emphasized and regulated the first component (rooftops) and largely neglected the transport component. While the rooftop component is largely fixed in density zoning, the transport is not. As an example, nearly all zoning codes set the maximum density for an area based on dwelling units (rooftops). Thus, in a given area, no more than one single-family home can be located on each acre of land and so forth.

EIA reduction can therefore be achieved through the disconnection of impervious areas, like rooftops, from the downstream drainage collection system. This disconnection occurs when rooftop drains are diverted to discharge on pervious areas such as lawns or bioretention/infiltration areas.

The intentional use of various techniques such as infiltration and biofiltration designed to reduce EIA in new development has been referred to as "better site design" or "low impact development". The intentional use of similar techniques in the design of roadways has been referred to as "green streets" or "skinny streets". Opportunities still exist within the study area where these types of development practices should be either mandated, totally embraced or simply encouraged. The choice is ultimately based on the value the community chooses to place on its existing aquatic resources which was discussed in Chapter 6.

7.3 FLOOD MANAGEMENT PLAN DEVELOPMENT

The development of a flood management plan needs to follow a set process. Each of the identified hydraulic deficiencies need to be examined to determine which of the flood management techniques can be used to address and correct the problem. Each technique needs to be tested against a number of factors such as: peak flow magnitude, existing hydraulic capacity, topographical constraints, downstream impacts and effectiveness in achieving the project objectives.

Because of the steep stream slopes and the general lack of any significant in-stream storage throughout the West Linn study area, the only practical solution to each of the identified hydraulic deficiencies is to either increase the conveyance by upsizing the existing pipe/culvert or do nothing and accept a higher risk of flooding than the 4% annual chance associated with the 25-year return interval design.

The City could consider increasing its current on-site detention requirements as a way of offsetting the need for upsizing pipes/culverts in the future; however, since the number of hydraulically deficient structures is expected on only increase by one-tenth with growth, the potential benefits of such a politically difficult action would be quite limited.

Development of Pipe/Culvert Replacement Costs

The Surface Water Management Plan is a planning document that guides implementation of the actions needed to achieve the plan's goals and objectives. Cost estimates presented throughout this document are considered planning level. Their accuracy may not fall within the construction contingency that was assumed. When costs are low compared to detailed construction bids, the reason is usually attributed to difficult access conditions or conflicts with other utilities located within the right-of-way.

Typically, a planning level estimate is established during a project's preliminary design phase to determine feasibility, evaluate alternate solutions, and establish financial need. This type of estimate is based on available planning/engineering data and limited cost information and does not involve detailed data gathering or analysis.

The unit costs used to estimate the cost of replacement pipes/culverts were originally based on actual construction costs published by the Oregon Department of Transportation (ODOT). The pipe/culvert replacement costs used ODOT's Average Contract Unit Bid Costs for the 2000-2002 calendar years. The original costs were multiplied by .42 to account for a 42% increase in the construction index from 2002 to 2005. Table 7.1 presents the unit costs that were used in estimating the pipe/culvert replacement cost for each identified deficiency.

In developing the estimated construction cost for these replacements, the following assumptions were made:

- Trench depth is 10 feet
- Trench width is equal to twice the replacement pipe diameter
- Concrete pipe will be used
- Asphalt removal and replacement quantities are based on trench width
- Backfill volume is equal to trench volume minus pipe volume

The estimated construction costs, presented later, include the following items:

- Mobilization and demobilization
- Pipe material costs
- End sections (headwalls) for culverts
- Trench excavation
- Select granular backfill and bedding
- Pavement cutting
- Asphalt removal and replacement with 9 inches of aggregate base and 6 inches of asphalt pavement
- Curb removal and replacement
- TV inspection of constructed system

Table 7.1 Unit Construction Costs for Pipe/Culvert Replacement

DESCRIPTION	UNIT	UNIT COST
Site Preparation		
Mobilization and Demobilization	L.S.	$5,000.00
Pavement Sawcutting	L.F.	$1.50
Asphalt Removal	S.F.	$1.85
Curb Removal	L.F.	$4.60
Earthwork		
Trench Excavation	C.Y.	$19.71
Select Granular Backfill	C.Y.	$21.00
Paving and Resurfacing		
Asphalt Pavement including Base	S.F.	$2.00
Curb Replacement	L.F.	$10.67
Material Costs		
Pipe		
12-inch diameter	L.F.	$29.25
18-inch diameter	L.F.	$39.61
24-inch diameter	L.F.	$46.67
30-inch diameter	L.F.	$59.70
36-inch diameter	L.F.	$61.97
42-inch diameter	L.F.	
48-inch diameter	L.F.	$121.91
60-inch diameter	L.F.	$150.00
72-inch diameter	L.F.	$200.00
Headwalls (culverts only)		
12-inch diameter	EA.	$500.00
18-inch diameter	EA.	$500.00
24-inch diameter	EA.	$1,250.00
30-inch diameter	EA.	$1,500.00
36-inch diameter	EA.	$2,300.00
42-inch diameter	EA.	$3,000.00
48-inch diameter	EA.	$4,000.00
60-inch diameter	EA.	$5,700.00
72-inch diameter	EA.	$7,500.00
Miscellaneous		
T.V. Inspection	L.F.	$2.00

In some areas where existing pipes and culverts are located, traditional replacement methods might not be cost effective or feasible. In particular, these may include pipes/culverts under I-205 and perhaps culverts with large excavation depths. For these types of facilities, trenchless technologies such as boring, tunneling and pipe bursting may be the best method. These construction methods are highly variable based on site conditions and are not included as an option within these cost estimates.

The items not included in the construction cost estimates are:

- Modification and replacement of manholes and catchbasins (inlets)
- Clearing and grubbing
- Erosion control
- Permitting
- Traffic control
- Site dewatering
- Utility relocation

These costs were not included because they generally are more site specific and some may not apply in each location. For example, replacing an undersized pipe within a paved right-of-way may not involve clearing and grubbing. Replacing a culvert may not include manhole/catchbasin modifications or replacements, but it may involve permitting and extensive clearing and grubbing as well as erosion control.

Table 7.2 presents the specific information on the replacement of the deficient pipes/culverts along with the estimated construction cost that includes a 15% construction contingency and a 20% allowance for engineering design and construction inspection. The size of replacement pipes/culverts shown in Table 7.2 is based on conveying the estimated 25-year peak flow under future development conditions.

Flood Management CIP Development

Two ultimate objectives of a surface water management plan are the identification of potential problems in a drainage system and the development of a means to mitigate or, when possible, eliminate the effects of the problems. The physical components of the chosen solutions are specified as projects that form the Capital Improvement Plan (CIP).

Hydraulic structures identified as not having adequate conveyance capacity may be chosen for upsizing as part of the City's Capital Improvement Plan. The decision of which structures to replace may depend on location, adverse impacts, fish passage considerations and cost. Location and impact factors will be determined by City staff and approved by the City Council.

When evaluating these location and impact factors, there are several possible considerations. Some of these deficient pipes or culverts may be the property of ODOT or Clackamas County, which could lower their priority for the City. Some culverts may require upgrades to provide for the passage of fish using the ODFW guidelines. Fish passage was discussed in Chapter 6. If fish passage is required, the size of the replacement culvert may increase or the culvert may need a natural bottom or be baffled. In any case, the cost of construction will increase.

One proven technique used to select and prioritize projects for the CIP is to rank them by their lowest cost per cfs of expected conveyance improvement and then further evaluate them based on a deficiency index. Cost per cfs of expected conveyance improvement is the total estimated project cost divided by the expected improvement in conveyance capacity expressed in cfs. The expected cfs improvement is the difference between the design flow and the existing flow capacity. The deficiency index is defined as the design flow minus the existing flow capacity divided by the design flow.

Those projects with high costs per cfs of conveyance improvement that have a very low deficiency index (*i.e.,* existing pipe is not very deficient) may not be included in the CIP because they will not provide a cost effective benefit. Those deemed to be worthy of the cost can be ranked based on a combination of low cost per cfs conveyance improvement and high deficiency index. The deficiency index and the cost per cfs of improvement have been computed and included in Table 7.2. The location of each project is shown in Figure 7.1, Figure 7.2, and Figure 7.3.

When assigning final implementation priorities within the CIP, factors like total project cost and the size of the drainage area should be taken into consideration. There are at least two views on project prioritization and funding. In one view, projects with an estimated lower total cost could be considered a higher implementation priority because many lower cost projects could be constructed for one higher cost project. This implementation strategy allows more areas to see direct benefits from the stormwater plan much sooner. From the other view, improvements designed for large drainage areas should not be overlooked especially if the hydraulic structure is severely deficient. Although more expensive, these improvements can reduce flooding risks that could result in greater damages in the event of a flood.

Table 7.3 represents three possible funding scenarios for implementing the capital improvements plan as shown in Table 7.2 within a 20-year timeframe.

Table 7.2 Potential Culvert and Pipe Replacement Projects

Watershed	HEC-HMS Subbasin	Drainage Area (mi2)	Location / Description	Existing Diam (in)	Structure Type Pipe or Culvert	Material	Slope (ft/ft)	Existing Capacity (cfs)	Design Flow 25-Year Future (cfs)	Is it Deficient? Now	Is it Deficient? Future	Deficiency Index	Proposed Diam (in)	Assumed Length (ft)	2002 Estimated Total Project Cost	Cost per cfs Improved	2005 Estimated Total Project Cost	2005 Estimated SDC Fund Project Cost	2005 Estimated 505 Fund Project Cost
1 TRILLIUM	TRR1-2	0.046	UNDER CALAROGA DR.	60	C	CONC	0.059	191	224	YES	YES	0.15	66	54	$103,305	$962	$146,693.10	$21,654.45	$125,038.65
2 ROBINWOOD	RWR1W2-1W3	0.04	MARYLHURST DR FROM LOWER MIDHILL TO	18	P	CONC	0.095	8	13	YES	YES	0.44	24	380	$71,688	$12,195	$101,797.22	$44,643.27	$57,153.95
3 ROBINWOOD	RWR1W2-1W3	0.04	MARYLHURST DR ENTRANCE TO PIPE	18	C	CONC	0.149	9	13	YES	YES	0.31	24	235	$50,449	$12,281	$71,636.92	$21,954.99	$49,681.93
4 GANS	GSJ4	0.077	SYSTEM UNDER COTTONWOOD DRIVE	18	P	CONC	0.197	14	23	YES	YES	0.40	24	125	$28,268	$3,000	$40,141.22	$16,208.71	$23,932.51
5 MADDAX	MXJ2	0.181	UNDER RIVER ST.	21	C	CMP	0.096	16	40	YES	YES	0.59	36	50	$25,359	$1,065	$36,009.59	$21,352.14	$14,657.45
6 BERNERT	BEJ4	0.528	NR 7TH	24	C	CONC	0.050	26	171	YES	YES	0.85	90	100	$84,394	$579	$119,840.13	$101,891.23	$17,948.90
7 TANNER	TARA-B	0.122	CULVERT UNDER PATH	15	C	CMP	0.030	6	25	YES	YES	0.76	30	20	$15,398	$804	$21,864.61	$16,598.78	$5,265.84
8 BERNERT	BER2-3	0.682	UNDER 5TH AVENUE AT MOEHNKE ST.	30	C	CONC	0.076	50	221	YES	YES	0.77	84	37	$48,792	$286	$69,284.66	$53,613.64	$15,671.02
9 SUMMERLINN	SL3S1	0.049	IN BLANKENSHIP DR	15	P	CONC	0.057	6	14	YES	YES	0.61	24	240	$47,850	$5,426	$67,946.87	$41,609.88	$26,336.98
10 ROBINWOOD	RWJ1S1	0.026	UNDER RIVER RD NR ROSE CT	10	P	CONC	0.038	3	8	YES	YES	0.66	18	186	$32,212	$5,735	$45,741.12	$30,242.61	$15,498.51
11 ROBINWOOD	RWJ1S1	0.026	PIPE SYSTEM BETWEEN VISTA CT AND ROSE	12	P	CONC	0.043	3	8	YES	YES	0.67	24	230	$46,147	$8,065	$65,528.98	$44,142.44	$21,386.54
12 ROBINWOOD	RWJ1S1	0.026	ENTRANCE PIPE UNDER VISTA CT.	14	C	CONC	0.032	7	8	YES	YES	0.13	18	62	$16,759	$15,637	$23,798.49	$3,002.75	$20,795.74
13 TANNER	TAJ9E1	0.075	UNDER PARKER RD.	18	C	CONC	0.030	14	19	NO	YES	0.29	24	66	$21,672	$3,894	$30,774.72	$8,793.51	$21,981.20
14 BERNERT	BER5W1-5W1S1	0.038	ALONG 13TH AVENUE	12	P	CONC	0.029	5	12	YES	YES	0.63	24	120	$27,417	$3,537	$38,932.28	$24,551.02	$14,381.25
15 BERNERT	BEJ5W1S1	0.038	FROM 16TH AVENUE TO 13TH AVENUE	12	P	CONC	0.050	5	12	YES	YES	0.63	24	1000	$177,258	$22,790	$251,705.91	$158,931.68	$92,774.24
16 BOLTON	BOJ3	0.134	PIPE FROM HWY 43 TO FAILING ST. S. OF	27	P	CONC	0.065	29	43	YES	YES	0.33	36	250	$66,949	$4,665	$95,067.02	$31,807.00	$63,260.02
17 BOLTON	BOR2-3	0.134	PIPE FROM HWY 43 TO HOLMES ST S. OF	24	P	CONC	0.052	23	43	YES	YES	0.45	36	520	$131,665	$6,793	$186,963.66	$84,725.92	$102,237.74
18 TRILLIUM	TRR4-5	0.046	THREE CULVERTS UNDER CEDAR OAK DRIVE	30	C	CONC	0.028	44	108	YES	YES			50				$0.00	$0.00
19 BARLOW	BAJ3	0.184	PIPE UNDER LOWRY DR.	27	C	CONC	0.214	34	46	YES	YES	0.25	36	70	$30,153	$2,627	$42,816.75	$10,695.50	$32,121.26
20 FERN	FNR4-5	0.233	PAIR CULVERTS NR INTERSECTION OF OLD	32	C	CMP	0.010	26	40	YES	YES	0.34	42	30	$22,518	$1,665	$31,975.80	$10,817.12	$21,158.68
21 FERN	FNR4-5	0.233	PAIR CULVERTS NR INTERSECTION OF OLD	32	C	CMP	0.010	26	40	YES	YES	0.34	42	30	$22,518	$1,665	$31,975.80	$10,817.12	$21,158.68
22 FRITCHIE	FR1S2	0.046	AT TAMARISK DRIVE	15	P	CONC	0.060	6	15	YES	YES	0.56	24	166	$35,250	$4,324	$50,054.54	$28,084.21	$21,970.33
23 SUMMERLINN	SLR1-2	0.313	PAIR ALONG JOHNSON RD UNDER PRIVATE	36	C	CONC	0.100	67	89	YES	YES	0.25	42	40	$24,915	$1,128	$35,379.38	$8,799.02	$26,580.36
24 SUMMERLINN	SLR1-2	0.313	PAIR ALONG JOHNSON RD UNDER PRIVATE	15	C	CONC	0.028	9	89	YES	YES	0.90	30	50	$21,776	$272	$30,921.91	$27,851.39	$3,070.52
25 TANNER	TAJ5-SAJ1	0.93	CULVERTS BETWEEN PONDS	54	C	CMP	0.930	66	203	YES	YES			78				$0.00	$0.00
26 TANNER	TAJ5-SAJ1	0.93	CULVERTS BETWEEN PONDS	54	C	CMP	0.930	66	203	YES	YES			78				$0.00	$0.00
27 TANNER	TAJ5-SAJ1	0.93	CULVERTS BETWEEN PONDS	54	C	CMP	0.930	66	203	YES	YES			78				$0.00	$0.00
28 GANS	GSR2-3	0.114	PAIR UPSTREAM OF KENTHORPE WAY	18	C	CONC	0.004	7	36	YES	YES	0.80	36	25	$19,367	$680	$27,500.65	$21,940.49	$5,560.15
29 ROBIN	RBR3-4	0.035	UNDER KANTARA LN.	15	C	CONC	0.083	9	11	YES	YES	0.19	18	30	$12,416	$6,180	$17,630.17	$3,270.68	$14,359.49
30 ROBINWOOD	RWJ2	0.128	CULVERT PAIR UNDER SHADY HOLLOW	27	C	CONC	0.093	13	32	YES	YES			68				$0.00	$0.00
31 TRILLIUM	TRJ7	0.046	UNDER PACIFIC HIGHWAY NR CHOW MEIN	30	C	CONC	0.111	45	94	YES	YES	0.52	48	90	$51,318	$1,055	$72,871.61	$37,915.56	$34,956.05
32 BARLOW	BAJ2	0.241	CULVERT UNDER FAILING STREET	24	C	CMP	0.098	9	63	YES	YES	0.85	54	317	$135,101	$2,513	$191,843.04	$163,991.61	$27,851.43
33 BOLTON	BOJ4	0.108	PIPE ALONG HWY 43 AT WEST A ST.	24	P	CONC	0.036	26	35	YES	YES	0.26	30	228	$55,481	$6,264	$78,783.07	$20,203.37	$58,579.70
34 FRITCHIE	FRJ1S2	0.097	UNDER I-205	30	C	CMP	0.025	15	30	YES	YES	0.51	42	400	$111,203	$7,369	$157,908.23	$80,045.34	$77,862.89
35 MCLEAN	MCJ5	0.122	NEAR H.S. TRACK	12	P	CONC	0.004	3	27	YES	YES	0.91	42	235	$63,374	$2,604	$89,991.57	$81,535.19	$8,456.38
36 ROBIN	RBJ3	0.062	PIPE SYSTEM UNDER WALLING CIRCLE	18	P	CONC	0.027	13	17	YES	YES	0.25	24	90	$22,309	$5,455	$31,678.63	$7,804.12	$23,874.51
37 ROBIN	RBJ3	0.062	PIPE SYSTEM UNDER WALLING CIRCLE	18	P	CONC	0.027	12	17	YES	YES	0.29	24	90	$22,309	$4,644	$31,678.63	$9,165.99	$22,512.64
38 SUMMERLINN	SLJ9	0.069	MATTERHORN COURT	15	P	CONC	0.220	7	19	YES	YES	0.64	24	119	$27,247	$2,199	$38,690.49	$24,592.79	$14,097.70
39 SUMMERLINN	SLJA	0.021	LUCERNE PLACE	15	P	CONC	0.084	6	7	NO	YES	0.21	18	240	$39,542	$26,845	$56,150.16	$11,724.11	$44,426.04
40 SUNSET	SSJ3	0.101	UNDER I-205	15	P	CONC	0.023	7	33	YES	YES	0.79	36	172	$48,253	$1,827	$68,519.10	$54,093.40	$14,425.70
41 SUNSET	SSJ3	0.101	UNDER WILLAMETTE FALLS DR.	24	C	CONC	0.007	20	33	YES	YES	0.40	30	90	$30,280	$2,261	$42,998.31	$17,211.42	$25,786.89
42 TANNER	TAR4-5	0.93	UNDER WELLINGTON CT.	72	C	CMP	0.005	163	203	YES	YES	0.20	84	100	$84,373	$2,111	$119,810.21	$23,631.24	$96,178.97
43 ARBOR	ARJ9	0.033	FROM BRAEMAR CT TO SKYE PARKWAY	18	P	CMP	0.164	4	11	YES	YES	0.63	30	390	$89,924	$13,437	$127,692.48	$80,189.32	$47,503.16
44 BARLOW	BAJ6	0.127	UNDER SUMMIT ST AT HORTON RD.	21	C	CMP	0.050	11	30	YES	YES	0.63	36	140	$46,931	$2,487	$66,641.81	$42,179.40	$24,462.40
45 BERNERT	BE2W1	0.111	UNDER 9TH ST. NR VOLPP ST.	18	C	CONC	0.004	7	34	YES	YES	0.80	36	80	$32,550	$1,184	$46,220.33	$36,852.18	$9,368.15
46 SUMMERLINN	SLR1-2	0.313	UNDER MEADOWVIEW CT.	60	C	CMP	0.011	134	89	No	No			70				$0.00	$0.00
47 DOLLAR	DOJ1	0.123	OUTFALL PIPE	18	P	CMP	0.110	13	35	YES	YES	0.64	30	325	$76,104	$3,420	$108,068.33	$68,752.96	$39,315.37
48 FERN	FNJ7	0.196	CULVERT NR KANTARA WAY	24	C	CONC	0.108	29	31	YES	YES	0.08	30	65	$24,965	$10,265	$35,450.56	$2,781.97	$32,668.59
49 FERN	FNJ7	0.196	NEAR KANTARA WAY	24	C	CMP	0.071	20	31	YES	YES	0.34	30	28	$17,099	$1,602	$24,279.89	$8,360.84	$15,919.05
50 FRITCHIE	FR1S2	0.046	UNDER TAMARISK DR	12	P	CONC	0.119	3	15	YES	YES	0.82	24	388	$73,050	$6,121	$103,731.52	$85,197.51	$18,534.02
51 FRITCHIE	FRJ1S3	0.051	UNDER KILARNEY AT LIMERICK	24	P	CMP	0.082	6	15	YES	YES	0.57	36	680	$170,015	$19,409	$241,420.93	$138,619.56	$102,801.37
52 MCLEAN	MCJ3W2	0.076	CULVERT UNDER MAPLE NR WALNUT ST.	16	C	CMP	0.044	8	15	YES	YES	0.44	24	90	$25,759	$3,930	$36,577.63	$16,155.98	$20,421.65
53 MCLEAN	MCJ3W1	0.112	PIPE ALONG I-205	21	P	CMP	0.028	6	27	YES	YES	0.79	42	458	$116,825	$5,475	$165,891.39	$131,837.87	$34,053.52
54 MCLEAN	MCJ3W1	0.112	PIPE ALONG I-205	18	P	CMP	0.700	8	27	YES	YES	0.69	30	70	$21,888	$1,181	$31,081.31	$21,460.17	$9,621.14
55 ROBINWOOD	RWJ3	0.11	CULVERT UNDER PACIFIC HIGHWAY	24	C	CONC	0.092	25	27	YES	YES	0.09	30	84	$29,005	$12,297	$41,186.85	$3,590.45	$37,596.39
56 ROBINWOOD	RWJ1S1	0.026	END PIPE UNDER FAIRVIEW	10	C	CONC	0.050	3	8	YES	YES	0.67	18	100	$21,918	$3,832	$31,123.37	$20,958.98	$10,164.38
57 ROBINWOOD	RWJ1W2S1	0.068	UNDER PACIFIC HIGHWAY NR S. EXIT OF	15	P	CONC	0.050	8	23	YES	YES	0.66	30	98	$27,841	$1,849	$39,534.79	$25,895.56	$13,639.22
58 SALAMO	SAJ2	0.241	UNDER BEACON HILL DR. NEAR	48	C	CONC	0.027	0	53	YES	YES			150				$0.00	$0.00
59 SALAMO	SAJ3	0.21	NR CRYSTAL TERRACE AND HASKINS	36	C	CONC	0.035	0	47	YES	YES			78				$0.00	$0.00
60 SUMMERLINN	SLJ5N1	0.023	UNDER DEBOK AT VILLAGE PARK PL.	15	P	CMP	0.094	4	7	YES	YES	0.51	24	180	$37,634	$10,484	$53,439.57	$26,991.49	$26,448.08
61 SUMMERLINN	SLJ3S1	0.049	JOHNSON RD. NR 19TH AVENUE	15	P	CONC	0.013	5	14	YES	YES	0.64	24	300	$58,066	$6,255	$82,454.16	$53,153.48	$29,300.68
62 SUNSET	SSR1-2	0.109	CULVERT TO OUTFALL	24	C	CONC	0.075	29	36	YES	YES	0.21	30	420	$100,443	$13,051	$142,628.57	$30,275.34	$112,353.23
63 ARBOR	ARJ8	0.049	UPSTREAM OF BRAEMAR CT.	18	P	CONC	0.017	13	16	YES	YES	0.23	24	120	$27,417	$7,479	$38,932.28	$8,822.04	$30,110.24
64 BARLOW	BAJ4	0.159	UNDER WILLAMETTE DR. NR RANDALL ST.	24	C	CMP	0.167	23	39	YES	YES	0.41	36	110	$39,740	$2,471	$56,431.07	$23,322.85	$33,108.22
65 BERNERT	BER5-5W1	0.224	UNDER 10TH	36	C	CONC	0.040	71	75	YES	YES	0.05	42	150	$51,281	$13,504	$72,818.75	$3,708.14	$69,110.61
66 BERNERT	BEJ3N1	0.124	UNDER WILLAMETTE FALLS DR. AT 6TH	42	C	CMP	0.043	106	40	No	No			90				$0.00	$0.00
67 BERNERT	BEJ5W2	0.018	UNDER I-205 AT VIRGINIA LN.	15	P	CONC	0.010	5	9	YES	YES	0.42	24	288	$56,023	$15,055	$79,552.70	$33,180.75	$46,371.95
68 BERNERT	BER3-4	0.528	UNDER WILLAMETTE FALLS DR NR 6TH ST.	42	C	CMP	0.040	92	171	YES	YES	0.46	60	160	$95,263	$1,209	$135,272.83	$62,221.44	$73,051.39
69 FERN	FNJ1	1.042	CULVERT UNDER OLD RIVER ROAD	60	C	CMP	0.127	134	220	YES	YES	0.39	84	71	$67,995	$784	$96,552.41	$38,014.58	$58,537.83

70	MADDAX	MXR3-4	0.039	UNDER BROADWAY	15	C	CMP	0.086	7	7	YES	YES	0.05	18	58	$16,217	$42,411	$23,027.45	$1,184.70	$21,842.74
71	MARY S YOUNG	MYJ5N1	0.048	PIPE UNDER PIMLICO DR.	18	P	CONC	0.185	12	14	YES	YES	0.13	24	275	$53,809	$29,637	$76,409.45	$10,165.53	$66,243.92
72	MARY S YOUNG	MYJ5	0.141	PIPE UNDER POSEIDON CT.	24	P	CONC	0.116	26	41	YES	YES	0.37	30	700	$155,834	$10,443	$221,284.54	$81,322.58	$139,961.96
73	MCLEAN	MCR3-3W1	0.112	PIPE ALONG I-205	24	P	CMP	0.027	20	27	YES	YES	0.25	30	602	$134,998	$19,835	$191,697.37	$48,616.63	$143,080.74
74	ROBIN	RBJ2S2	0.037	SYSTEM UNDERWILDERNESS DRIVE	18	P	CONC	0.088	9	10	YES	YES	0.03	24	215	$43,593	$159,327	$61,902.16	$1,744.86	$60,157.30
75	ROBINWOOD	RWJ4	0.102	CULVERT UNDER UPPER MIDHILL NR	24	C	CMP	0.120	16	26	YES	YES	0.38	30	75	$27,091	$2,755	$38,469.66	$14,725.57	$23,744.09
76	SALAMO	SAJ8	0.06	ALONG SALAMO	30	P	CONC	0.050	12	16	YES	YES	0.24	36	650	$162,824	$42,764	$231,210.19	$55,950.42	$175,259.77
77	SALAMO	SAJ5N1	0.033	NR SALAMO RD AND VISTA RIDGE DR.	12	P	CONC	0.115	5	7	YES	YES	0.37	18	657	$96,149	$35,992	$136,531.06	$50,575.50	$85,955.57
78	SUNSET	SSJ4	0.079	ENTRANCE PIPE FROM SUNSET AVE. TO	24	C	CONC	0.143	15	26	YES	YES	0.43	36	412	$112,126	$9,930	$159,219.16	$69,011.64	$90,207.53
79	TANNER	TAJ3E1	0.033	PIPE UNDER FAIRHAVEN DR	15	P	CONC	0.080	8	10	YES	YES	0.20	18	601	$88,547	$43,505	$125,736.50	$25,676.80	$100,059.70
Total																$4,074,208		$5,785,375.64	$2,701,410.86	$3,083,964.78

$Note_1$: Projects are funded from two sources:The 505 (Environmental Services) account, which is collected from utility rate payers, and System Development Charges, which are collected from storm water permits during development.

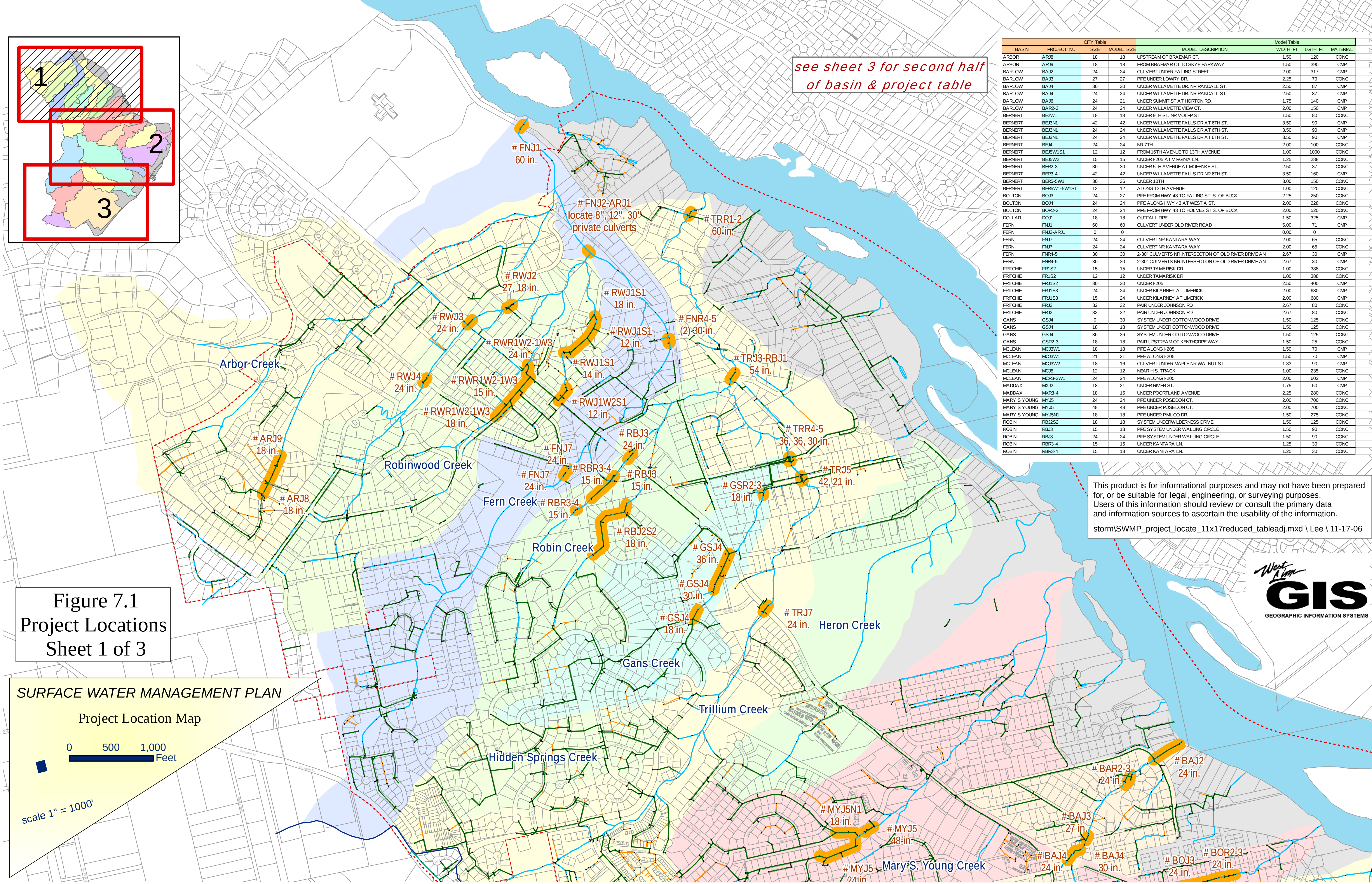
$Note_2$: The time frame for completion of the above projects is estimated to be from 2 to 20 years.

$Note_3$: All culverts and open channels shall be designed with special attention to energy dissipation and velocity reduction.

Table 7.3
Possible Funding Scenarios

	Remaining Backlog	8% Project Funding/yr	Remaining Backlog	Constant $$/Yr	Remaining Backlog	Inflation Adjust $/Yr
	$3,100,000		$3,100,000		$3,100,000	
2007 / 2008	$2,994,600	$248,000	$3,045,000	$200,000	$3,092,250	$155,000
2008 / 2009	$2,892,784	$239,568	$2,987,250	$200,000	$3,075,975	$162,750
2009 / 2010	$2,794,429	$231,423	$2,926,613	$200,000	$3,050,342	$170,888
2010 / 2011	$2,699,418	$223,554	$2,862,943	$200,000	$3,014,456	$179,432
2011 / 2012	$2,607,638	$215,953	$2,796,090	$200,000	$2,967,355	$188,403
2012 / 2013	$2,518,978	$208,611	$2,725,895	$200,000	$2,908,008	$197,824
2013 / 2014	$2,433,333	$201,518	$2,652,190	$200,000	$2,835,307	$207,715
2014 / 2015	$2,350,600	$194,667	$2,574,799	$200,000	$2,748,067	$218,101
2015 / 2016	$2,270,679	$188,048	$2,493,539	$200,000	$2,645,015	$229,006
2016 / 2017	$2,193,476	$181,654	$2,408,216	$200,000	$2,524,787	$240,456
2017 / 2018	$2,118,898	$175,478	$2,318,627	$200,000	$2,385,923	$252,479
2018 / 2019	$2,046,856	$169,512	$2,224,558	$200,000	$2,226,862	$265,103
2019 / 2020	$1,977,263	$163,748	$2,125,786	$200,000	$2,045,929	$278,358
2020 / 2021	$1,910,036	$158,181	$2,022,075	$200,000	$1,841,336	$292,276
2021 / 2022	$1,845,094	$152,803	$1,913,179	$200,000	$1,611,169	$306,889
2022 / 2023	$1,782,361	$147,608	$1,798,838	$200,000	$1,353,382	$322,234
2023 / 2024	$1,721,761	$142,589	$1,678,780	$200,000	$1,065,789	$338,346
2024 / 2025	$1,663,221	$137,741	$1,552,719	$200,000	$746,052	$355,263
2025 / 2026	$1,606,672	$133,058	$1,420,355	$200,000	$391,677	$373,026
2026 / 2027	$1,552,045	$128,534	$1,281,373	$200,000	$0	$391,677

Total City-Funded Portion project backlog $3,100,000 (rounded) as shown in Table 7.2
CCI Inflation factor 0.05
% of proj to accompl 0.08



CITY Table				Model Table			
BASIN	PROJECT_NU	SIZE	MODEL_SIZE	MODEL DESCRIPTION	WIDTH_FT	LGTH_FT	MATERIAL
ARBOR	ARJ8	18	18	UPSTREAM OF BRAEMAR CT.	1.50	120	CONC
ARBOR	ARJ9	18	18	FROM BRAEMAR CT TO SKYE PARKWAY	1.50	390	CMP
BARLOW	BAJ2	24	24	CULVERT UNDER FAILING STREET	2.00	317	CMP
BARLOW	BAJ3	27	27	PIPE UNDER LOWRY DR.	2.25	70	CONC
BARLOW	BAJ4	30	30	UNDER WILLAMETTE DR. NR RANDALL ST.	2.50	87	CMP
BARLOW	BAJ4	24	24	UNDER WILLAMETTE DR. NR RANDALL ST.	2.50	87	CMP
BARLOW	BAJ6	24	21	UNDER SUMMIT ST AT HORTON RD.	1.75	140	CMP
BARLOW	BAR2-3	24	24	UNDER WILLAMETTE VIEW CT.	2.00	150	CMP
BERNERT	BE2W1	18	18	UNDER 9TH ST. NR VOLPP ST.	1.50	80	CONC
BERNERT	BEJ3N1	42	42	UNDER WILLAMETTE FALLS DR AT 6TH ST.	3.50	90	CMP
BERNERT	BEJ3N1	24	24	UNDER WILLAMETTE FALLS DR AT 6TH ST.	3.50	90	CMP
BERNERT	BEJ3N1	24	24	UNDER WILLAMETTE FALLS DR AT 6TH ST.	3.50	90	CMP
BERNERT	BEJ4	24	24	NR 7TH	2.00	100	CONC
BERNERT	BEJ5W1S1	12	12	FROM 16TH AVENUE TO 13TH AVENUE	1.00	1000	CONC
BERNERT	BEJ5W2	15	15	UNDER I-205 AT VIRGINIA LN.	1.25	288	CONC
BERNERT	BER2-3	30	30	UNDER 5TH AVENUE AT MOEHNKE ST.	2.50	37	CONC
BERNERT	BER3-4	42	42	UNDER WILLAMETTE FALLS DR NR 6TH ST.	3.50	160	CMP
BERNERT	BER5-5W1	30	36	UNDER 10TH	3.00	150	CONC
BERNERT	BER5W1-5W1S1	12	12	ALONG 13TH AVENUE	1.00	120	CONC
BOLTON	BOJ3	24	27	PIPE FROM HWY 43 TO FAILING ST. S. OF BUCK	2.25	250	CONC
BOLTON	BOJ4	24	24	PIPE ALONG HWY 43 AT WEST A ST.	2.00	228	CONC
BOLTON	BOR2-3	24	24	PIPE FROM HWY 43 TO HOLMES ST S. OF BUCK	2.00	520	CONC
DOLLAR	DOJ1	18	18	OUTFALL PIPE	1.50	325	CMP
FERN	FNJ1	60	60	CULVERT UNDER OLD RIVER ROAD	5.00	71	CMP
FERN	FNJ2-ARJ1	0	0		0.00	0	
FERN	FNJ7	24	24	CULVERT NR KANTARA WAY	2.00	65	CONC
FERN	FNJ7	24	24	CULVERT NR KANTARA WAY	2.00	65	CONC
FERN	FNR4-5	30	30	2-30" CULVERTS NR INTERSECTION OF OLD RIVER DRIVE AN	2.67	30	CMP
FERN	FNR4-5	30	30	2-30" CULVERTS NR INTERSECTION OF OLD RIVER DRIVE AN	2.67	30	CMP
FRITCHIE	FR1S2	15	15	UNDER TAMARISK DR	1.00	388	CONC
FRITCHIE	FR1S2	12	12	UNDER TAMARISK DR	1.00	388	CONC
FRITCHIE	FRJ1S2	30	30	UNDER I-205	2.50	400	CMP
FRITCHIE	FRJ1S3	24	24	UNDER KILARNEY AT LIMERICK	2.00	680	CMP
FRITCHIE	FRJ1S3	15	24	UNDER KILARNEY AT LIMERICK	2.00	680	CMP
FRITCHIE	FRJ2	32	32	PAIR UNDER JOHNSON RD.	2.67	80	CONC
FRITCHIE	FRJ2	32	32	PAIR UNDER JOHNSON RD.	2.67	80	CONC
GANS	GSJ4	0	30	SYSTEM UNDER COTTONWOOD DRIVE	1.50	125	CONC
GANS	GSJ4	18	18	SYSTEM UNDER COTTONWOOD DRIVE	1.50	125	CONC
GANS	GSJ4	36	36	SYSTEM UNDER COTTONWOOD DRIVE	1.50	125	CONC
GANS	GSR2-3	18	18	PAIR UPSTREAM OF KENTHORPE WAY	1.50	25	CONC
MCLEAN	MCJ3W1	18	18	PIPE ALONG I-205	1.50	70	CMP
MCLEAN	MCJ3W1	21	21	PIPE ALONG I-205	1.50	70	CMP
MCLEAN	MCJ3W2	18	16	CULVERT UNDER MAPLE NR WALNUT ST.	1.33	90	CMP
MCLEAN	MCJ5	12	12	NEAR H.S. TRACK	1.00	235	CONC
MCLEAN	MCR3-3W1	24	24	PIPE ALONG I-205	2.00	602	CMP
MADDAX	MXJ2	18	21	UNDER RIVER ST.	1.75	50	CMP
MADDAX	MXR3-4	18	15	UNDER POORTLAND AVENUE	2.25	280	CONC
MARY S YOUNG	MYJ5	24	24	PIPE UNDER POSEIDON CT.	2.00	700	CONC
MARY S YOUNG	MYJ5	48	48	PIPE UNDER POSEIDON CT.	2.00	700	CONC
MARY S YOUNG	MYJ5N1	18	18	PIPE UNDER PIMLICO DR.	1.50	275	CONC
ROBIN	RBJ2S2	18	18	SYSTEM UNDERWILDERNESS DRIVE	1.50	125	CONC
ROBIN	RBJ3	15	18	PIPE SYSTEM UNDER WALLING CIRCLE	1.50	90	CONC
ROBIN	RBJ3	24	24	PIPE SYSTEM UNDER WALLING CIRCLE	1.50	90	CONC
ROBIN	RBR3-4	15	15	UNDER KANTARA LN.	1.25	30	CONC
ROBIN	RBR3-4	15	18	UNDER KANTARA LN.	1.25	30	CONC

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West Linn GIS
GEOGRAPHIC INFORMATION SYSTEMS

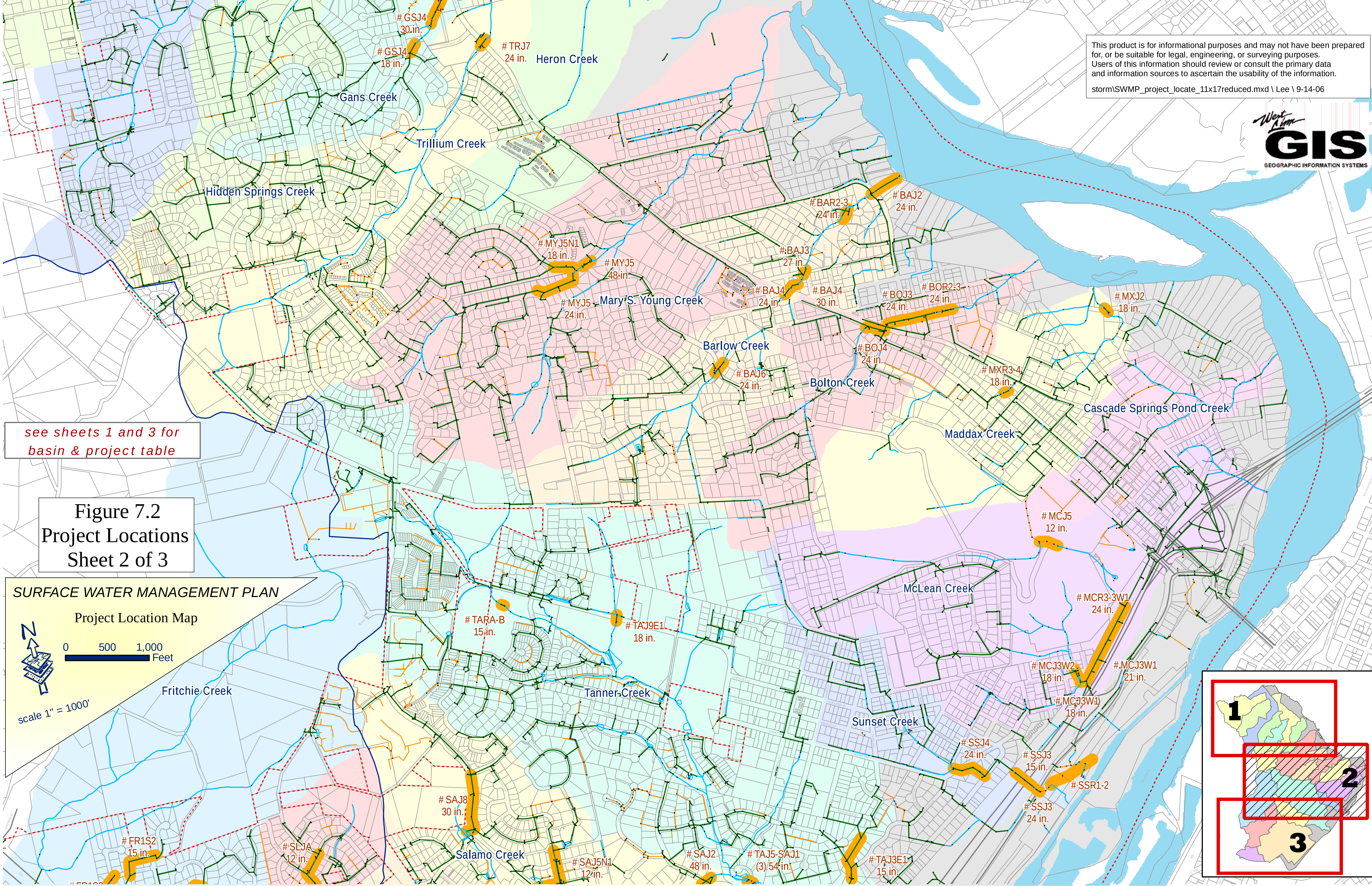
Figure 7.1 Project Locations Sheet 1 of 3

SURFACE WATER MANAGEMENT PLAN

Project Location Map

0 500 1,000 Feet

scale 1" = 1000'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Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.
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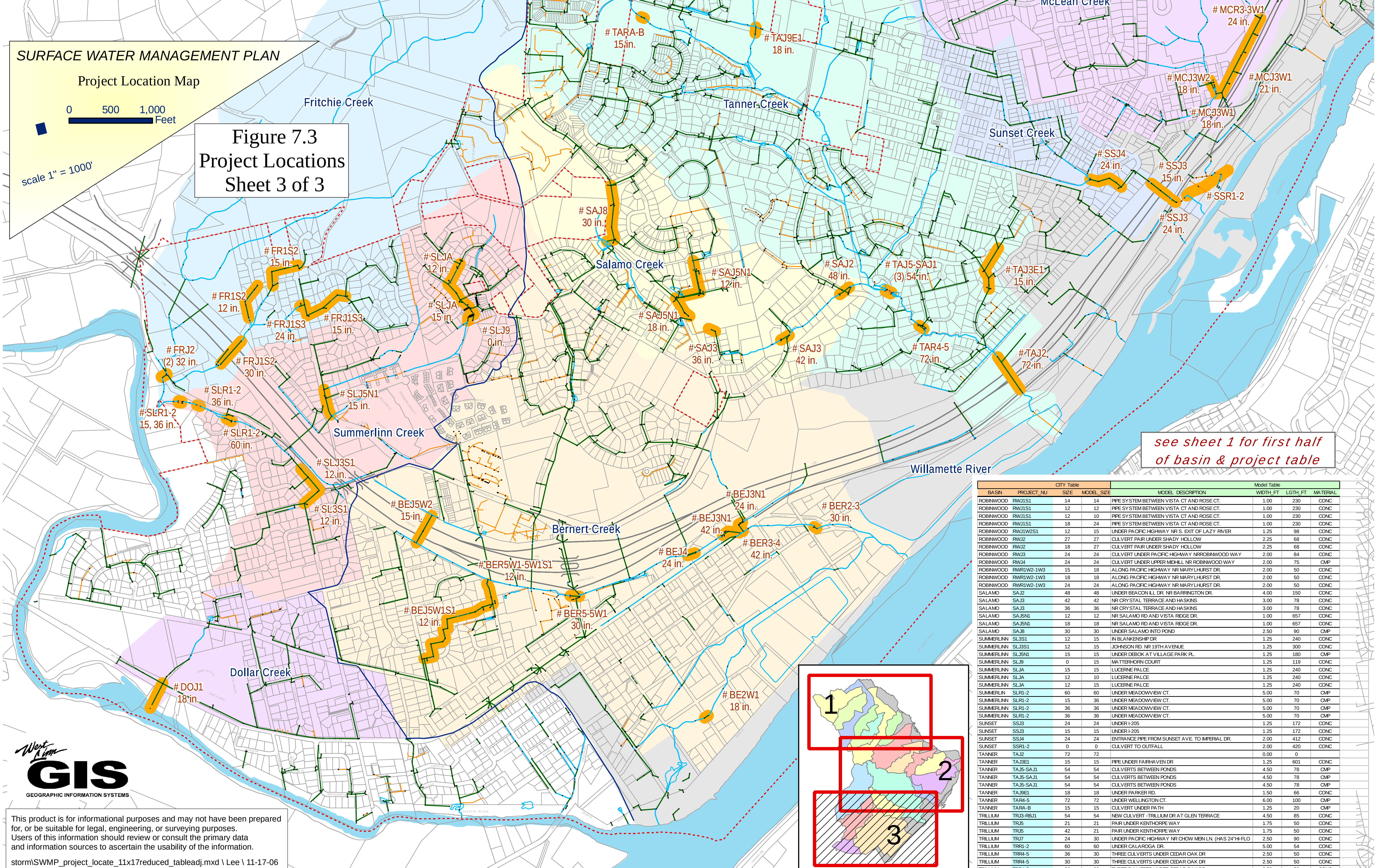
West Linn GIS
GEOGRAPHIC INFORMATION SYSTEMS
see sheets 1 and 3 for basin & project table
Figure 7.2
Project Locations
Sheet 2 of 3
SURFACE WATER MANAGEMENT PLAN
Project Location Map
0 500 1,000 Feet
scale 1" = 1000'
Heron Creek
Gans Creek
Trillium Creek
Hidden Springs Creek
Mary S. Young Creek
Barlow Creek
Bolton Creek
Maddax Creek
Cascade Springs Pond Creek
McLean Creek
Fritchie Creek
Tanner Creek
Sunset Creek
Salamo Creek
GSJ4 30 in.
GSJ4 18 in.
TRJ7 24 in.
BAR2-3 24 in.
BAJ2 24 in.
MYJ5N1 18 in.
MYJ5 48 in.
MYJ5 24 in.
BAJ3 27 in.
BAJ4 24 in.
BAJ4 30 in.
BOJ3 24 in.
BOR2-3 24 in.
MXJ2 18 in.
BOJ4 24 in.
BAJ6 24 in.
MXR3-4 18 in.
MCJ5 12 in.
MCR3-3W1 24 in.
TARA-B 15 in.
TAJ9E1 18 in.
MCJ3W2 18 in.
MCJ3W1 21 in.
MCJ3W1 18 in.
SSJ4 24 in.
SSJ3 15 in.
SSR1-2
SSJ3 24 in.
SAJ8 30 in.
FR1S2 15 in.
SLJA 12 in.
SAJ5N1 12 in.
SAJ2 48 in.
TAJ5-SAJ1 (3) 54 in.
TAJ3E1 15 in.
1
2
3



CITY Table				Model Table			
BASIN	PROJECT_NU	SIZE	MODEL_SIZE	MODEL DESCRIPTION	WIDTH_FT	LGTH_FT	MATERIAL
ROBINWOOD	RWJ1S1	14	14	PIPE SYSTEM BETWEEN VISTA CT AND ROSE CT.	1.00	230	CONC
ROBINWOOD	RWJ1S1	12	12	PIPE SYSTEM BETWEEN VISTA CT AND ROSE CT.	1.00	230	CONC
ROBINWOOD	RWJ1S1	12	10	PIPE SYSTEM BETWEEN VISTA CT AND ROSE CT.	1.00	230	CONC
ROBINWOOD	RWJ1S1	18	24	PIPE SYSTEM BETWEEN VISTA CT AND ROSE CT.	1.00	230	CONC
ROBINWOOD	RWJ1W2S1	12	15	UNDER PACIFIC HIGHWAY NR S. EXIT OF LAZY RIVER	1.25	98	CONC
ROBINWOOD	RWJ2	27	27	CULVERT PAIR UNDER SHADY HOLLOW	2.25	68	CONC
ROBINWOOD	RWJ2	18	27	CULVERT PAIR UNDER SHADY HOLLOW	2.25	68	CONC
ROBINWOOD	RWJ3	24	24	CULVERT UNDER PACIFIC HIGHWAY NRROBINWOOD WAY	2.00	84	CONC
ROBINWOOD	RWJ4	24	24	CULVERT UNDER UPPER MIDHILL NR ROBINWOOD WAY	2.00	75	CMP
ROBINWOOD	RWR1W2-1W3	15	18	ALONG PACIFIC HIGHWAY NR MARYLHURST DR.	2.00	50	CONC
ROBINWOOD	RWR1W2-1W3	18	18	ALONG PACIFIC HIGHWAY NR MARYLHURST DR.	2.00	50	CONC
ROBINWOOD	RWR1W2-1W3	24	24	ALONG PACIFIC HIGHWAY NR MARYLHURST DR.	2.00	50	CONC
SALAMO	SAJ2	48	48	UNDER BEACON ILL DR. NR BARRINGTON DR.	4.00	150	CONC
SALAMO	SAJ3	42	42	NR CRYSTAL TERRACE AND HASKINS	3.00	78	CONC
SALAMO	SAJ3	36	36	NR CRYSTAL TERRACE AND HASKINS	3.00	78	CONC
SALAMO	SAJ5N1	12	12	NR SALAMO RD AND VISTA RIDGE DR.	1.00	657	CONC
SALAMO	SAJ5N1	18	18	NR SALAMO RD AND VISTA RIDGE DR.	1.00	657	CONC
SALAMO	SAJ8	30	30	UNDER SALAMO INTO POND	2.50	90	CMP
SUMMERLINN	SL3S1	12	15	IN BLANKENSHIP DR	1.25	240	CONC
SUMMERLINN	SLJ3S1	12	15	JOHNSON RD. NR 19TH AVENUE	1.25	300	CONC
SUMMERLINN	SLJ5N1	15	15	UNDER DEBOK AT VILLAGE PARK PL.	1.25	180	CMP
SUMMERLINN	SLJ9	0	15	MATTERHORN COURT	1.25	119	CONC
SUMMERLINN	SLJA	15	15	LUCERNE PALCE	1.25	240	CONC
SUMMERLINN	SLJA	12	10	LUCERNE PALCE	1.25	240	CONC
SUMMERLINN	SLJA	12	15	LUCERNE PALCE	1.25	240	CONC
SUMMERLIN	SLR1-2	60	60	UNDER MEADOWVIEW CT.	5.00	70	CMP
SUMMERLINN	SLR1-2	15	36	UNDER MEADOWVIEW CT.	5.00	70	CMP
SUMMERLINN	SLR1-2	36	36	UNDER MEADOWVIEW CT.	5.00	70	CMP
SUMMERLINN	SLR1-2	36	36	UNDER MEADOWVIEW CT.	5.00	70	CMP
SUNSET	SSJ3	24	24	UNDER I-205	1.25	172	CONC
SUNSET	SSJ3	15	15	UNDER I-205	1.25	172	CONC
SUNSET	SSJ4	24	24	ENTRANCE PIPE FROM SUNSET AVE. TO IMPERIAL DR.	2.00	412	CONC
SUNSET	SSR1-2	0	0	CULVERT TO OUTFALL	2.00	420	CONC
TANNER	TAJ2	72	72		0.00	0	
TANNER	TAJ3E1	15	15	PIPE UNDER FAIRHAVEN DR	1.25	601	CONC
TANNER	TAJ5-SAJ1	54	54	CULVERTS BETWEEN PONDS	4.50	78	CMP
TANNER	TAJ5-SAJ1	54	54	CULVERTS BETWEEN PONDS	4.50	78	CMP
TANNER	TAJ5-SAJ1	54	54	CULVERTS BETWEEN PONDS	4.50	78	CMP
TANNER	TAJ9E1	18	18	UNDER PARKER RD.	1.50	66	CONC
TANNER	TAR4-5	72	72	UNDER WELLINGTON CT.	6.00	100	CMP
TANNER	TARA-B	15	15	CULVERT UNDER PATH	1.25	20	CMP
TRILLIUM	TRJ3-RBJ1	54	54	NEW CULVERT -TRILLIUM DR AT GLEN TERRACE	4.50	85	CONC
TRILLIUM	TRJ5	21	21	PAIR UNDER KENTHORPE WAY	1.75	50	CONC
TRILLIUM	TRJ5	42	21	PAIR UNDER KENTHORPE WAY	1.75	50	CONC
TRILLIUM	TRJ7	24	30	UNDER PACIFIC HIGHWAY NR CHOW MEIN LN. (HAS 24"HI-FLO	2.50	90	CONC
TRILLIUM	TRR1-2	60	60	UNDER CALAROGA DR.	5.00	54	CONC
TRILLIUM	TRR4-5	36	30	THREE CULVERTS UNDER CEDAR OAK DR	2.50	50	CONC
TRILLIUM	TRR4-5	30	30	THREE CULVERTS UNDER CEDAR OAK DR	2.50	50	CONC
TRILLIUM	TRR4-5	36	30	THREE CULVERTS UNDER CEDAR OAK DR	2.50	50	CONC

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Chapter 8

PUBLIC INVOLEMENT and PROCESS

8.1 ESTABLISHMENT

In December 2003, the City Council released the consultant from completion of the management plan project. Staff took over review of the draft, coordination of the public process, and finalization of the management plan document. The City Council directed that a Citizens Advisory Committee be established to participate in the public involvement/review phase.

The City Council named six West Linn residents to serve on the Citizens Advisory Committee. Citizens appointed included: John E. Borden, Matthew Butts, Andrew Harris, and Charles R. Lytle, Aziz Mahar, and Alice Richmond. The kickoff meeting was held February 24, 2004.

Between February and October 2004, thirteen meetings were held. The meetings included a site visit to various storm facilities and drainage ways throughout the City, discussions of the draft submittals from the consultant, Pacific Water Resources, a joint work session with the City Council, and formulation of a set of recommendations to the City, identification of stream enhancement project locations, and a proposed prioritization method for the Capital Improvement/Maintenance Project list.

The assigned City project staff changed in 2005, necessitating a re-familiarization with the project by the new staff members. A final draft was prepared in conjunction with the prior consultant, project list, project scopes, and planning level design/construction estimates were also defined, and the project documents were once again reviewed by the Citizens Advisory Committee in March 2006 requiring additional meetings. The committee's input was once again incorporated into the final draft for submission to the City Planning Commission and the City Council for consideration for adoption.

An Open House meeting was held in May 2006. Concerns raised during that meeting were subsequently addressed in the master plan document and one final meeting held with the Citizens Advisory Committee.

The master plan was presented to the Planning Commission in July 2006. Suggestions from the Planning Commission were incorporated into the plan.

Chapter 9

RECOMMENDATIONS

9.1 INSTALL FLOW MONITORING GAUGES

Flow monitoring for the city is based on regional data. Because West Linn has unique topography, it is reasonable that the City purchase 3 continuous flow gauges for three drainage areas that are representative of impacted watersheds. This would allow the City to more accurately verify capacity calculations and to monitor improvements towards reducing peak flows.

9.2 CONDUCT STREAM ASSESSMENTS

From summer 2003 through spring 2004, the City partnered with Oregon Department of Fish and Wildlife (ODFW) and investigated and inventoried fish communities in seven streams and 79 reach/time surveys located within the City Limits.

Among the fish collected, 91% were reticuline scalpin, 4% were western brook lamprey, and 3.5 % were salmon and trout. Seven native species from four families, and three alien species from three families, which constituted about 1.5 % of the total catch, were identified.

Cutthroat trout were the most common salmonid and were present in Summer Linn and Trillium Creeks. Juvenile rainbow/steelhead were found in Summer Linn creek, juvenile Chinook salmon in Mary S Young Creek and Trillium Creeks, and juvenile coho salmon in Mary S Young Creek. Western brook lampreys were observed throughout the year in Summer Linn creek.

Index of Biotic integrity (IBI) scores for all sampling efforts in fish-bearing streams ranged from 10-68. The mean IBI for all sampling efforts per stream reach indicated all reaches were severely impaired. NO IBI scores were considered acceptable.

Despite extensive urban development, West Linn streams still contain some native fish species, including salmonids. Fish assemblages have obviously changed throughout the period of urban development, but persistence of native species, especially those most sensitive to habitat degradation, confirms the potential benefits of habitat protection and restoration. Therefore, Comprehensive stream assessments should be done for the following creeks that ODFW identified as fish bearing streams: Trillium, Summer Linn creek, and Mary S Young Creek. This would entail habitat, and morphology for the full length of the streams, and would help to better define stream enhancement area as well as the quality of fish habitat that may be made accessible with fish passage improvements.

9.3 SURFACE WATER CONSIDERATIONS IN DEVELOPMENT

City staff will prepare recommendations for code changes to City Council for their review and consideration that deal with surface water as an aspect in development as gleaned from the :
"Better Site Design: A Handbook for Changing Development Rules in Your Community", August 1998 (Center for Watershed Protection, 1998)

- Street designs should preserve natural features, account for contour changes and incorporate natural drainage features and other open aggregate drainage features, such as bioswales.
- Storm drains should be located within the pavement section of the right-of-way wherever feasible.
- Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff. Use of vegetated swales should be used wherever feasible, especially in low density and mildly sloped (less than 4%) residential areas.

9.4 DESIGN AND CONSTRUCTION STANDARDS

City staff should make it an ongoing responsibility to review the latest stormwater technology and regulation changes. Based on this review changes to the Development and/or Construction Standards may be recommended as appropriate.

9.5 CULVERT DESIGN

It is recommended that bottomless culverts be installed at locations that are required by the Oregon Department of Fish and Wildlife, and/or the National Marine Fisheries Service. It is further recommended that bottomless culverts also be installed at other locations unless it is economically unfeasible, or site conditions do not allow for this type of culvert to be installed.

9.6 DETENTION FACILITIES

Current Public Works Standards Section 2.0045 states:
"Detention volume storage methods, in order of preference, are the following:

a. Surface storage – pond
b. Underground storage by tank or vault will be approved by the City Engineer only when a pond is impracticable"

It is recommended that Public Works Standards Section 2.0045 be modified to state:
"Detention volume storage methods, in order of preference are the following:

a. Surface storage – pond, swale, or other engineered surface detention facility
b. Underground storage by tank or vault will only be considered for commercial, industrial, or non-residential uses when the City Engineer has determined that a surface facility is impracticable. Underground storage (public or private) will not be authorized for any residential use or homeowners' association."

9.7 ORDINANCE REQUIRING ANNUAL INSPECTIONS

It is recommended that the City Council consider passing an ordinance requiring the annual inspection and cleaning of catchbasins located on private property. The ordinance shall require that the property owner or manager certify every year through a cleaning contractor that the inspections and cleanings have been completed.

9.8 ORDINANCE REQUIRING CLEANING AND/OR SWEEPING OF PRIVATE PARKING LOTS AND STREETS

It is recommended that the City Council consider passing an ordinance requiring semi-annual sweeping or cleaning of private parking lots and streets and require installation of bags in the catchbasins during the sweeping operation to reduce downstream nutrient loading.

9.9 ADDITIONAL CULVERT EVALUATIONS

It is recommended to complete more culvert evaluations during different seasons to get a more complete picture of stream conditions throughout the year. City staff should develop and maintain a database of all stormdrainage culverts and establish a 3 – 5 year evaluation cycle.

9.10 NATURAL DRAINAGEWAY RESTORATION

City should consider creating a program to restore natural drainageways as noted in Appendix F, removing invasive species, restoring native species, and enhancing fish habitat where identified. In addition to public drainageway tracts, work with owners of private drainageways to encourage/facilitate restoration of drainageways on private property. City staff should annually evaluate the success of work done in the preceding year to best utilize utility funds and staff resources.

9.11 ENCOURAGING DISCONNECTION OF IMPERVIOUS AREAS FROM DOWNSTREAM DRAINAGE.

The City should consider EIA reduction that can be achievee through disconnection of impervious areas, like rooftops, from the downstream drainage collection system. Allow and even encourage roof drain, etc diversion to discharge on pervious areas such as lawns or bioretention/infiltration areas.

9.12 DESIGN CRITERIA

The following criteria were developed for culvert design and stream enhancement. It is recommended that they be used to evaluate and prioritize CIP and stream enhancement projects that are identified in the surface water management plan. Each criterion was assigned a value of 0-5 with the general consideration as noted below.

<u>CIP Prioritization Evaluation Criteria</u>

<u>Culverts/Piped Systems</u>

- Fish passage
- Capacity (Now and future)
- Structural Integrity
- Location
- Maintenance

Fish Passage: 0-indicates no benefit if fish passage is provided due to no historical fish presence. 5-indicates that fish passage would provide access of known fish populations to habitat that will sustain a fishery.

Capacity: 0-indicates no capacity deficiency exists according to data from master/management plans for either the present or future. 5-capacity deficiency is present and is of high priority as detrimental potential to damage structures or human health.

Structural Integrity: 0-no structural problem; 5-system has immediate need for repair due to failing structural integrity.

Location: 0-location is a non issue; 5-location of project is of importance in terms of potential impacts if no improvement occurs or if in the event the improvement is constructed the benefits are large.

Maintenance: 0-no issues with maintenance; 5-Reoccuring and costly maintenance issues exist that the project will alleviate.

<u>Stream Enhancements</u>

- Fish
- Channel Morphology
- Vegetation (Lack of and/or type)
- Location
- Detention/Floodplains/Wetland

Fish: 0-No documented existing or historic fish presence, enhancement would not benefit fish; 5-documented existing or historic fish presence, and stream enhancement would greatly benefit the fisheries.

Channel Morphology: 0-Enhancement will not improve stream morphology either directly or indirectly; 5- enhancement will directly improve stream morphology.

Vegetation: 0-Enhancement will not impact vegetation; 5-enhancenment will improve vegetation condition, type and/or quantity along the stream corridor.

Location: 0-location of enhancement is not the same watershed as other improvement projects. 5-enhancement is in the same watershed as other projects and will have an additive effect in improving watershed health.

Detention/Floodplains/Wetlands: 0-enhancement will not impact improvement of detention of runoff. 5-enhancement will improve detention of storm runoff by increasing the floodplain utilized by the stream system or a wetland improvement that will also improve detention.

Implementation of the recommendations in this document will depend on staff availability, budget, and City approval. It will be determined in coordination with City Departments and staff review.

9.13 PUBLIC EDUCATION

It is recommended that City staff continue current levels of public education about stormwater concerns, evaluate the effectiveness of the outreach, and continue working in partnership with other agencies to fund broader reaching public education opportunities.

Appendix A

HEC-HMS Input Parameter Values

Subbasin	Total Area (acres)	Impervious Area (acres) Existing	Impervious Area (acres) Future	Lag Time (hours) Existing	Lag Time (hours) Future	Aerially Averaged Infiltration Rate Existing	Aerially Averaged Infiltration Rate Future
AR1	1.60	0.16	0.16	1.03	1.03	0.398	0.398
AR2	15.29	1.06	1.76	1.82	1.51	0.475	0.371
AR2S	9.50	1.97	1.99	0.48	0.48	0.163	0.158
AR2S1	10.64	2.12	2.23	0.50	0.49	0.183	0.158
AR3	15.19	3.11	2.21	0.50	0.50	0.231	0.299
AR3N1	2.21	0.04	0.04	1.81	1.81	0.59	0.59
AR3N2	19.38	2.55	1.71	0.64	0.64	0.41	0.41
AR3N3	7.75	0.17	0.16	0.79	0.79	0.46	0.46
AR4	7.13	0.95	1.42	0.62	0.47	0.42	0.18
AR5	15.93	2.44	3.32	0.44	0.40	0.35	0.17
AR5N	4.94	0.60	1.04	0.54	0.40	0.41	0.16
AR5N1	10.27	0.90	1.27	0.60	0.50	0.33	0.28
AR5N1W1	49.87	1.00	1.03	2.49	2.48	0.59	0.59
AR5N2	3.62	0.17	0.44	0.96	0.69	0.86	0.46
AR5N3	16.15	0.62	0.62	1.80	1.80	0.68	0.68
AR5N4	19.96	2.25	2.05	0.67	0.67	0.44	0.46
AR6	8.27	0.36	1.41	1.34	0.70	0.35	0.20
AR7	12.22	1.69	2.15	0.55	0.44	0.28	0.20
AR7N	3.48	0.71	0.73	0.41	0.41	0.18	0.16
AR8	10.24	2.15	2.14	0.38	0.38	0.16	0.16
AR9	21.32	4.48	4.04	0.41	0.41	0.16	0.20
BA1	1.80	0.38	0.38	0.34	0.34	0.16	0.16
BA2	18.96	3.56	3.81	0.47	0.46	0.22	0.20
BA2S	18.61	3.79	3.76	0.45	0.45	0.19	0.17
BA3	15.02	3.20	3.15	0.58	0.58	0.16	0.16
BA4	10.79	1.70	2.32	0.40	0.37	0.52	0.16
BA5	9.62	1.23	1.69	0.48	0.37	0.53	0.31
BA6	27.67	5.49	5.55	0.48	0.48	0.21	0.20
BA7	16.04	2.39	2.40	0.54	0.54	0.43	0.43
BA7S1	7.30	0.92	1.53	0.67	0.49	0.31	0.16
BA8	30.72	2.85	6.45	1.96	1.13	0.37	0.16
BE1	18.00	7.00	8.62	0.60	0.48	0.19	0.15
BE2	51.24	28.88	30.22	0.25	0.23	0.15	0.15
BE2W1	70.88	10.19	15.80	0.58	0.43	0.28	0.17
BE3	19.68	12.30	12.47	0.15	0.15	0.15	0.15
BE3N1	47.53	28.87	29.16	0.16	0.16	0.15	0.15
BE3N2	31.59	4.01	6.56	1.92	1.33	0.33	0.16
BE4	39.89	22.79	23.35	0.14	0.14	0.18	0.15
BE4N1	6.91	1.27	1.27	0.52	0.52	0.29	0.29
BE5	26.76	18.94	19.64	0.16	0.16	0.19	0.15
BE5S1	13.29	7.05	7.12	0.22	0.22	0.15	0.15
BE5W	25.68	16.86	17.39	0.22	0.21	0.15	0.15
BE5W1	23.58	11.47	11.54	0.39	0.38	0.15	0.15
BE5W1N1	7.87	6.69	6.69	0.12	0.12	0.15	0.15

Subbasin	Total Area (acres)	Impervious Area (acres) Existing	Impervious Area (acres) Future	Lag Time (hours) Existing	Lag Time (hours) Future	Aerially Averaged Infiltration Rate Existing	Aerially Averaged Infiltration Rate Future
BE5W1N1W	7.98	3.69	4.13	0.19	0.17	0.15	0.15
BE5W1N2	22.23	12.17	12.17	0.19	0.19	0.15	0.15
BE5W1S	21.41	4.14	4.79	0.56	0.53	0.20	0.16
BE5W1S1	24.38	5.20	5.36	0.45	0.45	0.16	0.16
BE5W2	11.82	6.88	6.88	0.16	0.16	0.15	0.15
BE5W3	24.52	6.32	6.96	0.44	0.42	0.20	0.15
BE6	29.82	18.49	18.66	0.16	0.16	0.15	0.15
BE7	13.19	2.51	2.74	0.47	0.45	0.20	0.17
BE8	26.40	2.73	5.45	0.67	0.43	0.35	0.17
BE9	8.72	1.81	1.82	0.37	0.37	0.16	0.16
BE9N	3.52	0.74	0.74	0.50	0.50	0.16	0.16
BO1	14.19	3.03	2.55	0.52	0.52	0.32	0.26
BO2	14.53	3.62	3.77	0.39	0.38	0.19	0.17
BO3	7.81	1.76	1.67	0.40	0.40	0.20	0.16
BO3S1	5.62	0.98	1.18	0.45	0.43	0.18	0.16
BO4	15.97	2.81	3.35	0.43	0.41	0.36	0.16
BO5	14.87	2.12	3.12	0.60	0.46	0.35	0.16
BO6	14.62	2.68	3.07	0.38	0.37	0.25	0.16
BO7	8.91	1.50	1.57	0.52	0.52	0.31	0.31
BO8	16.81	2.28	3.46	0.53	0.40	0.31	0.17
CS1	1.80	0.38	0.38	0.50	0.50	0.16	0.16
CS2	16.54	4.62	4.95	0.45	0.43	0.17	0.15
CS2N1	15.83	9.04	9.31	0.38	0.16	0.15	0.15
CS3	5.47	1.81	1.61	0.30	0.30	0.20	0.15
CS4	17.50	4.35	3.67	0.44	0.44	0.19	0.16
DO1	5.11	1.76	1.11	0.40	0.40	0.15	0.16
DO1N	16.33	2.22	3.43	1.12	0.80	0.42	0.16
DO2	11.99	3.30	2.52	0.38	0.38	0.19	0.16
DO2S	13.34	2.61	2.81	0.52	0.50	0.19	0.16
DO3	24.87	4.83	5.22	0.55	0.53	0.19	0.16
DO3N	6.79	1.35	1.43	0.54	0.53	0.18	0.16
FN1	31.06	1.08	1.08	2.65	2.65	0.35	0.35
FN2	9.87	1.42	2.04	1.43	1.06	0.30	0.17
FN3	13.99	1.34	1.61	1.44	1.34	0.36	0.46
FN4	10.69	2.18	2.24	0.46	0.45	0.16	0.16
FN4N	10.85	3.30	3.53	0.43	0.42	0.18	0.15
FN5	5.45	3.13	3.13	0.15	0.15	0.15	0.15
FN6	18.38	4.02	4.72	0.46	0.43	0.37	0.28
FN7	25.80	2.98	3.08	1.35	1.33	0.60	0.61
FN8	24.57	4.49	4.75	0.45	0.44	0.22	0.22
FN9	33.55	4.09	6.00	0.69	0.53	0.35	0.26
FNA	41.36	6.18	6.24	0.70	0.61	0.26	0.29
FR1	1.36	0.11	0.29	0.70	0.43	0.60	0.16
FR1S1	9.19	3.49	4.47	0.34	0.31	0.23	0.15
FR1S2	29.27	5.09	6.92	0.52	0.46	0.27	0.15
FR1S3	32.94	5.47	6.92	0.51	0.47	0.24	0.16
FR2	17.20	7.23	8.98	0.33	0.17	0.29	0.15
FR3	47.64	1.20	2.11	2.40	2.15	0.49	0.42
FR3N1	10.73	0.21	0.21	1.31	1.31	0.59	0.59

Subbasin	Total Area (acres)	Impervious Area (acres) Existing	Future	Lag Time (hours) Existing	Future	Aerially Averaged Infiltration Rate Existing	Future
FR3S	22.50	2.09	4.01	1.74	1.13	0.38	0.27
FR3S1	29.61	0.65	2.60	1.95	1.41	0.57	0.43
FR3S2	10.65	3.24	3.59	0.51	0.50	0.19	0.15
FR4	48.48	0.97	0.97	1.96	1.96	0.59	0.59
FR5	59.57	1.19	1.19	2.67	2.67	0.59	0.59
GS1	6.40	1.24	1.34	0.44	0.42	0.20	0.16
GS2	10.01	2.31	2.39	0.67	0.66	0.17	0.15
GS3	5.69	3.31	3.31	0.14	0.14	0.15	0.15
GS3N1	18.18	4.83	4.90	0.43	0.43	0.17	0.15
GS4	20.90	4.26	4.28	0.43	0.43	0.16	0.18
GS4S1	7.37	1.37	1.55	0.39	0.38	0.16	0.16
GS5	21.11	4.32	4.32	0.48	0.48	0.16	0.17
HE1	13.99	0.92	2.13	1.50	0.94	0.73	0.48
HE2	19.11	3.38	4.01	0.55	0.51	0.22	0.16
HE3	46.84	0.34	0.34	3.44	3.44	1.19	1.22
HE4	19.98	3.09	4.29	0.62	0.55	0.49	0.35
HE5	14.49	1.96	1.96	0.55	0.55	0.54	0.55
HS1	11.30	2.22	2.22	0.45	0.45	0.17	0.19
HS2	12.38	2.36	2.36	0.44	0.44	0.23	0.24
HS3	32.84	5.83	5.83	0.58	0.58	0.17	0.23
MC1	10.74	5.35	5.57	0.26	0.24	0.23	0.19
MC2	12.07	6.37	5.64	0.17	0.17	0.15	0.15
MC2S	13.35	11.34	11.34	0.15	0.15	0.15	0.15
MC3	18.20	12.09	11.94	0.26	0.26	0.23	0.23
MC3N	10.81	3.82	3.59	0.36	0.36	0.15	0.15
MC3W1	23.19	6.61	4.99	0.40	0.40	0.21	0.16
MC3W2	25.83	1.81	1.85	1.06	1.06	0.83	0.83
MC3W3	22.94	3.69	3.68	0.49	0.49	0.31	0.36
MC4	12.08	2.30	2.30	1.67	1.67	0.83	0.83
MC5	24.09	3.47	3.47	0.49	0.49	0.52	0.52
MC6	9.53	2.00	2.00	0.42	0.42	0.16	0.16
MC7	22.72	2.23	2.23	1.00	1.00	0.74	0.75
MC8	21.87	4.58	4.58	0.46	0.46	0.16	0.16
MX1	6.62	0.27	0.50	1.94	1.71	0.80	0.73
MX1N1	11.64	0.91	1.17	0.67	0.64	0.32	0.43
MX2	19.41	7.06	7.19	0.38	0.38	0.18	0.17
MX3	15.31	2.58	3.22	0.46	0.43	0.20	0.16
MX3S	28.66	6.34	6.02	0.93	0.49	0.19	0.16
MX3S1	21.16	0.87	0.93	1.04	1.03	1.02	1.02
MX3S2	9.81	0.14	0.14	1.64	1.64	1.22	1.22
MX4	6.50	0.98	1.36	0.43	0.39	0.19	0.16
MX5	18.63	0.36	0.44	1.02	1.01	1.17	1.17
MY1	25.15	0.03	0.18	2.77	2.72	0.96	1.06
MY2	7.61	1.12	1.12	0.96	0.96	0.46	0.46
MY2N	26.87	4.61	4.61	0.57	0.57	0.28	0.31
MY3	33.71	6.63	7.08	0.85	0.81	0.18	0.16
MY4	57.52	9.00	11.53	0.72	0.65	0.34	0.27
MY4N1	30.85	6.37	6.37	0.52	0.52	0.16	0.17
MY4S1	27.00	5.67	5.67	0.46	0.46	0.16	0.16

Subbasin	Total Area (acres)	Impervious Area (acres) Existing	Impervious Area (acres) Future	Lag Time (hours) Existing	Lag Time (hours) Future	Aerially Averaged Infiltration Rate Existing	Aerially Averaged Infiltration Rate Future
MY4S2	26.71	2.56	5.61	1.29	0.75	0.42	0.16
MY4S3	17.44	3.08	3.66	0.45	0.42	0.25	0.16
MY5	23.78	4.63	4.73	0.49	0.49	0.17	0.17
MY6	35.76	6.24	6.64	0.52	0.51	0.19	0.21
RB1	4.80	0.50	1.01	1.12	0.67	0.57	0.16
RB2	23.99	9.83	10.36	0.36	0.35	0.16	0.15
RB2S1	22.99	7.81	8.19	0.37	0.36	0.23	0.22
RB2S2	13.85	2.27	2.39	0.48	0.47	0.36	0.34
RB2S3	9.76	2.05	2.05	0.42	0.42	0.16	0.16
RB3	17.19	2.05	3.03	0.68	0.47	0.49	0.34
RB4	22.42	4.52	4.70	0.44	0.43	0.16	0.16
RW1	21.64	2.51	3.12	1.44	1.23	0.30	0.35
RW1S1	8.66	2.89	2.82	0.38	0.38	0.15	0.15
RW1S2	7.90	2.48	2.52	0.39	0.39	0.16	0.15
RW1W1	13.29	4.20	4.10	0.42	0.42	0.15	0.15
RW1W2	17.37	4.24	4.74	0.42	0.40	0.27	0.17
RW1W3	25.49	5.12	5.35	0.42	0.41	0.19	0.16
RW2	11.24	1.77	2.36	0.49	0.45	0.25	0.16
RW3	5.23	0.29	0.57	0.71	0.64	0.28	0.39
RW4	20.21	3.59	4.24	0.81	0.73	0.24	0.16
RW5	12.62	2.55	2.65	0.69	0.67	0.16	0.16
RW6	9.88	1.97	2.07	0.38	0.38	0.16	0.16
RW6N1	5.48	1.14	1.14	0.49	0.49	0.16	0.16
RW7	16.94	2.42	2.56	0.63	0.53	0.19	0.28
SA1	8.73	1.83	1.83	0.43	0.43	0.16	0.16
SA2	19.95	3.75	4.19	0.49	0.47	0.20	0.16
SA3	7.25	0.83	1.52	1.10	0.68	0.42	0.16
SA4	9.26	1.08	1.94	0.65	0.42	0.34	0.16
SA5	12.67	1.62	2.66	0.55	0.40	0.32	0.16
SA5N1	20.91	4.03	4.06	0.52	0.52	0.20	0.21
SA6	8.90	1.52	1.54	0.44	0.44	0.23	0.24
SA7	13.69	2.74	2.76	0.53	0.52	0.19	0.19
SA7W	23.11	1.56	4.86	1.52	0.78	0.39	0.16
SA8	10.93	2.81	2.27	0.42	0.42	0.15	0.19
SA9	27.59	10.48	10.48	0.38	0.38	0.18	0.18
SL1	16.79	4.02	5.46	0.49	0.43	0.25	0.15
SL2	15.16	3.87	3.98	0.43	0.42	0.15	0.15
SL3	21.47	11.44	11.05	0.24	0.24	0.15	0.15
SL3E1	14.67	5.10	5.09	0.32	0.32	0.15	0.18
SL3S1	31.28	5.43	6.57	0.59	0.55	0.20	0.16
SL4	16.41	6.31	6.32	0.39	0.39	0.15	0.15
SL5	11.60	3.72	3.81	0.52	0.51	0.15	0.15
SL5N1	10.56	2.07	2.07	0.44	0.44	0.16	0.19
SL6	5.70	1.13	1.17	0.38	0.38	0.21	0.30
SL7	7.97	1.00	1.00	0.54	0.54	0.34	0.36
SL7N	3.49	0.73	0.73	0.58	0.58	0.16	0.16
SL8	9.57	1.25	1.25	0.54	0.54	0.38	0.38
SL8S1	5.24	1.02	1.06	0.37	0.37	0.18	0.17
SL9	18.99	3.03	3.96	0.47	0.43	0.27	0.16

		Impervious Area (acres)		Lag Time (hours)		Aerially Averaged Infiltration Rate	
Subbasin	Total Area (acres)	Existing	Future	Existing	Future	Existing	Future
SL9E1	6.77	0.81	1.86	0.96	0.50	0.44	0.15
SL9W	4.30	0.89	0.89	0.42	0.42	0.17	0.17
SLA	5.81	0.83	1.28	0.51	0.38	0.31	0.16
SLB	7.89	0.53	1.83	0.70	0.40	0.48	0.15
SS1	5.68	4.83	4.83	0.11	0.11	0.15	0.15
SS2	5.25	4.46	4.46	0.11	0.11	0.15	0.15
SS3	13.84	5.56	4.86	0.31	0.31	0.19	0.15
SS4	5.75	1.79	1.21	0.43	0.43	0.15	0.16
SS5	6.49	1.93	1.36	0.34	0.34	0.19	0.16
SS6	12.44	3.15	2.61	0.37	0.37	0.16	0.16
SS6W1	7.65	1.95	1.61	0.42	0.42	0.16	0.16
SS6W1W	9.00	2.72	1.89	0.37	0.37	0.18	0.16
SS7	10.17	1.94	2.14	0.47	0.45	0.28	0.16
ST1	27.93	0.56	0.56	2.08	2.08	0.59	0.59
ST2	42.04	4.60	4.03	0.88	0.88	0.42	0.42
TA1	11.75	9.99	9.99	0.12	0.12	0.15	0.15
TA2	10.63	5.57	5.32	0.20	0.20	0.15	0.15
TA3	4.97	1.05	1.04	0.72	0.72	0.21	0.16
TA3E	9.08	2.35	1.91	0.37	0.37	0.22	0.16
TA3E1	21.00	4.63	4.41	0.45	0.45	0.27	0.16
TA3W	5.95	1.42	1.25	0.41	0.41	0.25	0.16
TA4	16.90	3.55	3.55	0.40	0.40	0.16	0.16
TA4E	7.92	1.66	1.66	0.44	0.44	0.16	0.16
TA4E1	8.46	1.71	1.78	0.44	0.43	0.19	0.16
TA4W	8.31	1.49	1.75	0.46	0.44	0.20	0.16
TA5	14.80	2.57	2.57	0.50	0.50	0.20	0.22
TA5E1	12.62	1.65	2.65	0.96	0.67	0.32	0.16
TA5E2	14.20	4.05	3.27	0.40	0.40	0.23	0.15
TA6	31.68	4.63	6.54	0.57	0.43	0.31	0.16
TA6W1	9.02	1.82	1.82	0.37	0.37	0.16	0.18
TA6W1N	11.59	2.38	2.38	0.39	0.39	0.16	0.17
TA7	10.70	2.18	2.20	0.75	0.75	0.16	0.16
TA7W1	12.90	2.37	2.37	0.40	0.40	0.30	0.30
TA7W2	17.10	3.46	3.46	0.48	0.48	0.18	0.19
TA8	29.53	4.65	6.20	1.00	0.83	0.24	0.16
TA8E1	22.16	2.25	4.65	0.66	0.41	0.32	0.16
TA8E2	28.26	1.08	5.93	0.83	0.45	0.52	0.16
TA8W1	15.34	3.90	3.58	0.67	0.67	0.15	0.20
TA8W2	24.59	8.19	7.67	0.41	0.41	0.16	0.15
TA8W3	14.35	9.30	9.30	0.15	0.15	0.15	0.15
TA9	16.64	4.99	2.99	0.61	0.61	0.19	0.25
TA9E1	23.51	1.09	4.94	0.64	0.36	0.58	0.16
TA9E2	8.47	1.82	1.77	0.43	0.43	0.16	0.16
TA9E3	15.73	2.79	3.30	0.48	0.45	0.23	0.16
TAA	20.63	3.11	5.14	0.50	0.42	0.31	0.25
TAB	15.54	1.00	3.59	1.36	0.65	0.40	0.15
TAC	12.02	1.29	2.53	0.95	0.65	0.37	0.16
TAD	13.19	3.57	3.38	0.60	0.60	0.23	0.30
TAE	14.85	3.07	2.62	0.85	0.85	0.19	0.26

Subbasin	Total Area (acres)	Impervious Area (acres) Existing	Impervious Area (acres) Future	Lag Time (hours) Existing	Lag Time (hours) Future	Aerially Averaged Infiltration Rate Existing	Aerially Averaged Infiltration Rate Future
TAF	22.73	3.46	4.77	0.57	0.51	0.20	0.16
TR1	30.66	6.11	6.44	1.20	1.15	0.17	0.16
TR2	10.67	1.50	2.24	1.11	0.80	0.33	0.16
TR2S1	20.81	4.16	4.37	0.57	0.56	0.17	0.16
TR3	20.45	3.21	4.29	0.54	0.49	0.30	0.16
TR4	3.32	0.70	0.70	0.41	0.41	0.16	0.16
TR5	24.82	4.01	5.21	0.53	0.49	0.27	0.16
TR6	15.97	1.69	1.73	0.63	0.63	0.65	0.70
TR7	37.76	4.31	6.31	1.29	0.93	0.52	0.39
TR8	35.25	6.94	6.94	0.54	0.54	0.36	0.39
TR9	18.93	4.54	4.54	0.46	0.46	0.18	0.18
TR9N	10.28	2.10	2.12	0.46	0.46	0.17	0.17
TRA	24.61	3.44	5.17	0.65	0.49	0.20	0.16
TRB	8.97	1.68	1.88	0.51	0.49	0.18	0.16
TRBS	29.39	4.04	4.65	0.73	0.62	0.42	0.28
TRC	13.80	2.84	2.84	0.43	0.43	0.16	0.17

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
AR1	0.003	0.18	0.18	0.24	0.24	0.26	0.26	0.35	0.35	0.38	0.38	0.42	0.42	0.48	0.48
AR2	0.024	2.19	2.34	2.66	2.87	2.90	3.14	3.63	3.97	3.83	4.19	4.13	4.53	4.63	5.09
AR2S	0.015	2.34	2.34	3.00	3.00	3.34	3.34	4.33	4.33	4.60	4.60	4.99	4.99	5.65	5.65
AR2S1	0.017	2.29	2.61	2.98	3.35	3.34	3.72	4.44	4.83	4.74	5.13	5.18	5.57	5.92	6.30
AR3	0.024	2.91	2.63	3.84	3.49	4.32	3.95	5.82	5.38	6.24	5.77	6.87	6.37	7.92	7.40
AR3N1	0.004	0.20	0.20	0.25	0.25	0.28	0.28	0.36	0.36	0.38	0.38	0.42	0.42	0.48	0.48
AR3N2	0.03	3.44	3.44	4.44	4.44	4.95	4.95	6.52	6.52	6.95	6.95	7.59	7.59	8.69	8.69
AR3N3	0.012	1.26	1.26	1.61	1.61	1.79	1.79	2.34	2.34	2.49	2.49	2.72	2.72	3.11	3.11
AR4	0.011	0.92	1.57	1.25	2.04	1.42	2.28	1.96	3.04	2.11	3.24	2.34	3.54	2.73	4.05
AR5	0.025	2.59	4.31	3.55	5.52	4.04	6.12	5.57	7.92	5.99	8.40	6.64	9.11	7.74	10.29
AR5N	0.008	0.91	1.48	1.19	1.85	1.33	2.04	1.77	2.60	1.89	2.75	2.06	2.97	2.37	3.33
AR5N1	0.016	1.48	1.77	1.98	2.36	2.24	2.67	3.07	3.63	3.30	3.90	3.65	4.30	4.25	4.99
AR5N1W1	0.078	4.38	4.38	5.29	5.29	5.79	5.80	7.41	7.42	7.85	7.86	8.52	8.54	9.66	9.68
AR5N2	0.006	0.32	0.42	0.38	0.57	0.41	0.65	0.55	0.90	0.60	0.97	0.68	1.08	0.80	1.26
AR5N3	0.025	2.31	2.31	2.76	2.76	2.97	2.97	3.68	3.68	3.88	3.88	4.18	4.18	4.69	4.69
AR5N4	0.031	2.30	2.30	3.17	3.17	3.62	3.62	5.02	5.02	5.41	5.41	5.99	5.99	7.00	7.00
AR6	0.013	0.92	1.50	1.18	1.94	1.31	2.17	1.72	2.89	1.84	3.09	2.02	3.38	2.33	3.87
AR7	0.019	2.55	3.23	3.27	4.10	3.63	4.55	4.76	5.90	5.07	6.26	5.54	6.80	6.34	7.69
AR7N	0.005	0.82	0.93	1.07	1.19	1.20	1.33	1.59	1.72	1.70	1.82	1.85	1.97	2.11	2.23
AR8	0.016	3.15	3.15	3.96	3.96	4.35	4.35	5.54	5.54	5.86	5.86	6.32	6.32	7.10	7.10
AR9	0.033	6.38	5.82	8.01	7.41	8.82	8.21	11.23	10.66	11.86	11.31	12.81	12.27	14.39	13.88
ARJ2	0.411	42.79	46.96	54.32	59.59	60.15	65.91	77.73	85.05	82.51	90.21	89.74	97.91	101.95	110.82
ARJ2S1	0.017	2.29	2.61	2.98	3.35	3.34	3.72	4.44	4.83	4.74	5.13	5.18	5.57	5.92	6.30
ARJ3	0.356	36.13	40.01	45.95	50.86	50.93	56.30	66.17	72.80	70.31	77.26	76.55	83.96	87.07	95.19
ARJ3N1	0.046	4.87	4.87	6.25	6.25	6.95	6.95	9.12	9.12	9.71	9.71	10.61	10.61	12.13	12.13
ARJ3N2	0.042	4.68	4.68	6.03	6.03	6.71	6.71	8.81	8.81	9.39	9.39	10.26	10.26	11.75	11.75
ARJ3N3	0.012	1.26	1.26	1.61	1.61	1.79	1.79	2.34	2.34	2.49	2.49	2.72	2.72	3.11	3.11
ARJ4	0.286	28.46	32.62	36.04	41.27	39.82	45.59	51.34	58.66	54.51	62.14	59.26	67.36	67.27	76.07
ARJ5	0.275	27.55	31.08	34.81	39.25	38.43	43.33	49.41	55.66	52.39	58.94	56.93	63.87	64.55	72.08
ARJ5N1	0.156	10.68	11.02	13.28	13.78	14.58	15.15	18.61	19.40	19.74	20.55	21.44	22.31	24.34	25.30
ARJ5N1W1	0.078	4.38	4.38	5.29	5.29	5.79	5.80	7.41	7.42	7.85	7.86	8.52	8.54	9.66	9.68
ARJ5N2	0.062	4.92	5.02	6.29	6.48	6.97	7.21	9.08	9.44	9.67	10.05	10.58	10.98	12.12	12.57
ARJ5N3	0.056	4.61	4.61	5.92	5.92	6.56	6.56	8.55	8.55	9.09	9.09	9.91	9.91	11.33	11.33
ARJ5N4	0.031	2.30	2.30	3.17	3.17	3.62	3.62	5.02	5.02	5.41	5.41	5.99	5.99	7.00	7.00
ARJ6	0.087	13.57	14.45	17.10	18.37	18.87	20.36	24.18	26.39	25.60	27.99	27.74	30.39	31.30	34.37
ARJ7	0.074	12.85	13.10	16.22	16.62	17.90	18.40	22.97	23.76	24.33	25.19	26.36	27.32	29.74	30.84
ARJ8	0.049	9.52	8.96	11.95	11.35	13.15	12.55	16.75	16.18	17.69	17.14	19.11	18.57	21.46	20.95
ARJ9	0.033	6.38	5.82	8.01	7.41	8.82	8.21	11.23	10.66	11.86	11.31	12.81	12.27	14.39	13.88
ARR1-2	0.411	42.75	46.93	54.26	59.53	60.06	65.84	77.67	84.97	82.49	90.11	89.74	97.80	101.94	110.70
ARR2-2S1	0.017	2.29	2.60	2.97	3.34	3.33	3.71	4.43	4.82	4.72	5.11	5.17	5.55	5.90	6.28
ARR2-3	0.356	36.10	39.94	45.95	50.80	50.92	56.24	65.95	72.78	70.10	77.24	76.33	83.90	86.87	95.09
ARR3-3N1	0.046	4.87	4.87	6.24	6.24	6.94	6.94	9.12	9.12	9.71	9.71	10.60	10.60	12.12	12.12
ARR3-4	0.286	28.39	32.58	35.95	41.20	39.73	45.51	51.34	58.54	54.49	62.01	59.23	67.23	67.22	75.92
ARR3N1-3N2	0.042	4.68	4.68	6.02	6.02	6.70	6.70	8.80	8.80	9.39	9.39	10.26	10.26	11.74	11.74

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
ARR3N2-3N3	0.012	1.26	1.26	1.61	1.61	1.79	1.79	2.34	2.34	2.49	2.49	2.72	2.72	3.10	3.10
ARR4-5	0.275	27.53	31.06	34.78	39.23	38.39	43.31	49.38	55.62	52.39	58.90	56.92	63.82	64.53	72.02
ARR5-5N1	0.156	10.68	11.01	13.28	13.76	14.57	15.14	18.61	19.38	19.73	20.54	21.43	22.30	24.33	25.29
ARR5-6	0.087	13.56	14.45	17.09	18.36	18.85	20.35	24.16	26.38	25.59	27.98	27.72	30.38	31.28	34.36
ARR5N1-5N1W1	0.078	4.38	4.38	5.29	5.29	5.79	5.80	7.41	7.42	7.85	7.86	8.52	8.54	9.66	9.68
ARR5N1-5N2	0.062	4.92	5.02	6.29	6.48	6.97	7.21	9.08	9.44	9.67	10.05	10.58	10.97	12.12	12.57
ARR5N2-5N3	0.056	4.61	4.61	5.91	5.91	6.56	6.56	8.54	8.54	9.08	9.08	9.90	9.90	11.32	11.32
ARR5N3-5N4	0.031	2.30	2.30	3.16	3.16	3.61	3.61	5.01	5.01	5.39	5.39	5.98	5.98	7.00	7.00
ARR6-7	0.074	12.80	13.02	16.17	16.52	17.85	18.29	22.92	23.65	24.27	25.07	26.30	27.19	29.67	30.71
ARR7-8	0.049	9.49	8.94	11.92	11.32	13.13	12.52	16.72	16.15	17.66	17.11	19.08	18.54	21.43	20.92
ARR8-9	0.033	6.37	5.81	8.00	7.40	8.81	8.21	11.22	10.65	11.86	11.30	12.81	12.27	14.38	13.87
BA1	0.003	0.58	0.58	0.73	0.73	0.80	0.80	1.02	1.02	1.08	1.08	1.16	1.16	1.30	1.30
BA2	0.029	4.04	4.08	5.25	5.30	5.88	5.93	7.83	7.89	8.35	8.41	9.13	9.20	10.43	10.51
BA2S	0.029	4.88	5.34	6.20	6.70	6.87	7.38	8.92	9.41	9.46	9.94	10.28	10.75	11.63	12.07
BA3	0.025	4.00	4.00	5.02	5.02	5.53	5.53	7.06	7.06	7.47	7.47	8.08	8.08	9.09	9.09
BA4	0.017	1.79	3.37	2.49	4.22	2.84	4.65	3.93	5.91	4.22	6.25	4.66	6.75	5.40	7.58
BA5	0.015	0.91	1.90	1.40	2.55	1.66	2.88	2.44	3.93	2.66	4.22	2.98	4.66	3.54	5.40
BA6	0.043	6.99	6.99	8.88	8.88	9.84	9.84	12.78	12.78	13.56	13.56	14.73	14.73	16.67	16.67
BA7	0.025	2.77	2.77	3.66	3.66	4.11	4.11	5.52	5.52	5.90	5.90	6.47	6.47	7.45	7.45
BA7S1	0.011	1.38	1.94	1.75	2.43	1.94	2.68	2.53	3.42	2.70	3.61	2.94	3.90	3.36	4.39
BA8	0.048	4.41	5.88	5.35	7.28	5.83	8.00	7.29	10.17	7.68	10.76	8.28	11.64	9.29	13.11
BAJ1	0.244	30.80	34.74	39.23	44.27	43.53	49.12	56.56	63.82	60.03	67.74	65.33	73.61	74.17	83.44
BAJ2	0.241	30.28	34.23	38.57	43.61	42.81	48.40	55.63	62.90	59.07	66.77	64.27	72.55	72.98	82.26
BAJ3	0.184	21.62	25.07	27.39	31.89	30.31	35.37	39.22	45.96	41.62	48.80	45.24	53.06	51.33	60.18
BAJ4	0.159	17.62	21.09	22.40	26.90	24.81	29.87	32.21	38.91	34.21	41.34	37.23	44.98	42.32	51.09
BAJ5	0.142	15.87	17.93	20.03	22.92	22.14	25.49	28.52	33.35	30.24	35.47	32.83	38.66	37.19	43.99
BAJ6	0.127	15.00	16.34	18.68	20.72	20.55	22.97	26.22	29.82	27.74	31.66	30.02	34.43	33.84	39.07
BAJ7	0.084	8.14	10.00	9.99	12.52	10.93	13.81	13.76	17.76	14.52	18.85	15.66	20.49	17.61	23.27
BAJ8	0.048	4.41	5.88	5.35	7.28	5.83	8.00	7.29	10.17	7.68	10.76	8.28	11.64	9.29	13.11
BAR1-2	0.241	30.27	34.21	38.57	43.60	42.79	48.39	55.63	62.88	59.04	66.75	64.26	72.54	72.97	82.25
BAR2-3	0.184	21.61	25.06	27.38	31.88	30.32	35.37	39.21	45.96	41.58	48.79	45.24	53.01	51.34	60.13
BAR3-4	0.159	17.62	21.08	22.39	26.89	24.80	29.86	32.20	38.90	34.20	41.33	37.22	44.98	42.30	51.09
BAR4-5	0.142	15.87	17.93	20.03	22.91	22.14	25.48	28.52	33.35	30.24	35.46	32.83	38.65	37.19	43.98
BAR5-6	0.127	14.97	16.34	18.67	20.72	20.54	22.96	26.21	29.80	27.73	31.65	30.00	34.42	33.82	39.06
BAR6-7	0.084	8.14	10.00	9.99	12.51	10.92	13.80	13.76	17.76	14.52	18.84	15.66	20.47	17.61	23.25
BAR7-8	0.048	4.41	5.88	5.35	7.28	5.83	7.99	7.29	10.17	7.68	10.75	8.28	11.63	9.29	13.10
BE1	0.028	4.17	4.97	5.26	6.25	5.82	6.88	7.54	8.77	8.00	9.27	8.70	10.02	9.85	11.26
BE2	0.08	17.47	17.87	22.17	22.65	24.50	25.03	31.43	32.09	33.26	33.96	36.01	36.75	40.55	41.38
BE2W1	0.111	11.50	18.71	15.21	23.98	17.13	26.61	23.27	34.47	24.97	36.56	27.55	39.68	31.97	44.83
BE3	0.031	8.76	8.76	10.90	10.90	11.95	11.95	15.07	15.07	15.89	15.89	17.13	17.13	19.18	19.18
BE3N1	0.074	20.83	20.83	25.90	25.90	28.40	28.40	35.83	35.83	37.80	37.80	40.74	40.74	45.61	45.61
BE3N2	0.049	3.20	4.72	4.01	6.02	4.43	6.69	5.73	8.73	6.10	9.29	6.66	10.12	7.63	11.52
BE4	0.062	16.30	17.86	20.81	22.20	23.04	24.34	29.57	30.70	31.28	32.38	33.84	34.90	38.09	39.06
BE4N1	0.011	1.47	1.47	1.89	1.89	2.10	2.10	2.76	2.76	2.95	2.95	3.22	3.22	3.68	3.68

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

ID	Drainage Area (mi^2)	2-YEAR Existing Qpeak (cfs)	2-YEAR Future Qpeak (cfs)	5-YEAR Existing Qpeak (cfs)	5-YEAR Future Qpeak (cfs)	10-YEAR Existing Qpeak (cfs)	10-YEAR Future Qpeak (cfs)	25-YEAR Existing Qpeak (cfs)	25-YEAR Future Qpeak (cfs)	50-YEAR Existing Qpeak (cfs)	50-YEAR Future Qpeak (cfs)	100-YEAR Existing Qpeak (cfs)	100-YEAR Future Qpeak (cfs)	500-YEAR Existing Qpeak (cfs)	500-YEAR Future Qpeak (cfs)
BE4N1-R	0.011	0.79	0.79	0.93	0.93	1.00	1.00	2.09	2.09	2.41	2.41	2.83	2.83	3.50	3.50
BE5	0.042	10.69	11.72	13.65	14.57	15.12	15.98	19.41	20.16	20.53	21.26	22.22	22.92	25.01	25.66
BE5S1	0.021	4.69	4.69	5.95	5.95	6.57	6.57	8.42	8.42	8.91	8.91	9.64	9.64	10.85	10.85
BE5W	0.04	9.79	9.98	12.23	12.46	13.44	13.68	17.01	17.31	17.95	18.27	19.37	19.70	21.70	22.07
BE5W1	0.037	6.44	6.56	8.25	8.39	9.15	9.30	11.84	12.03	12.55	12.75	13.61	13.83	15.38	15.62
BE5W1N1	0.012	3.58	3.58	4.45	4.45	4.88	4.88	6.15	6.15	6.49	6.49	6.99	6.99	7.82	7.82
BE5W1N1-R	0.012	1.55	1.55	1.85	1.85	1.97	1.97	4.16	4.16	4.88	4.88	5.97	5.97	7.52	7.52
BE5W1N1W	0.012	3.12	3.28	3.89	4.08	4.27	4.48	5.40	5.65	5.69	5.96	6.14	6.43	6.88	7.19
BE5W1N2	0.035	9.02	9.02	11.25	11.25	12.35	12.35	15.60	15.60	16.46	16.46	17.75	17.75	19.88	19.88
BE5W1S	0.034	4.32	5.07	5.62	6.51	6.29	7.23	8.38	9.41	8.95	9.98	9.79	10.85	11.20	12.28
BE5W1S1	0.038	6.99	6.99	8.78	8.78	9.67	9.67	12.32	12.32	13.02	13.02	14.07	14.07	15.81	15.81
BE5W2	0.018	5.19	5.19	6.45	6.45	7.07	7.07	8.92	8.92	9.41	9.41	10.14	10.14	11.36	11.36
BE5W3	0.038	5.61	6.53	7.30	8.36	8.17	9.28	10.86	12.02	11.58	12.74	12.66	13.83	14.45	15.62
BE6	0.047	12.20	12.20	15.35	15.35	16.91	16.91	21.56	21.56	22.80	22.80	24.64	24.64	27.70	27.70
BE7	0.021	3.38	3.78	4.28	4.74	4.75	5.23	6.16	6.66	6.54	7.04	7.10	7.61	8.04	8.55
BE7-R	0.021	1.91	2.01	2.15	2.26	2.26	3.11	5.01	5.86	5.62	6.51	6.51	7.34	7.89	8.52
BE8	0.041	4.91	7.74	6.27	9.72	6.96	10.70	9.11	13.63	9.70	14.41	10.59	15.56	12.10	17.48
BE8-R	0.041	2.91	3.23	3.24	6.12	3.39	8.03	7.00	12.86	7.94	13.99	9.40	15.43	11.52	17.40
BE9	0.014	2.71	2.71	3.40	3.40	3.74	3.74	4.76	4.76	5.03	5.03	5.43	5.43	6.10	6.10
BE9N	0.005	0.96	0.96	1.21	1.21	1.33	1.33	1.70	1.70	1.80	1.80	1.94	1.94	2.19	2.19
BEJ1	0.901	143.82	154.85	182.67	197.43	202.10	218.83	260.51	282.36	276.53	299.35	301.06	326.08	342.60	376.75
BEJ2	0.873	140.65	150.43	178.55	192.30	197.48	213.05	254.30	274.55	269.94	291.13	293.95	317.43	334.43	367.11
BEJ2W1	0.111	11.50	18.71	15.21	23.98	17.13	26.61	23.27	34.47	24.97	36.56	27.55	39.68	31.97	44.83
BEJ3	0.682	118.96	124.14	150.98	156.96	166.85	173.31	214.23	221.63	226.95	234.56	246.35	254.57	279.86	295.71
BEJ3N1	0.124	23.03	23.16	28.44	28.92	31.11	31.80	39.04	40.43	41.13	42.73	44.27	46.18	49.47	51.92
BEJ3N2	0.049	3.20	4.72	4.01	6.02	4.43	6.69	5.73	8.73	6.10	9.29	6.66	10.12	7.63	11.52
BEJ4	0.528	92.04	96.90	116.81	122.17	129.32	134.54	165.96	171.48	176.19	181.78	192.35	199.52	218.30	234.19
BEJ4N1	0.011	0.79	0.79	0.93	0.93	1.00	1.00	2.09	2.09	2.41	2.41	2.83	2.83	3.50	3.50
BEJ5	0.455	80.42	83.84	101.60	105.48	112.11	116.22	143.51	147.94	152.35	156.82	166.83	174.05	189.65	204.69
BEJ5S1	0.021	4.69	4.69	5.95	5.95	6.57	6.57	8.42	8.42	8.91	8.91	9.64	9.64	10.85	10.85
BEJ5W1	0.224	39.50	41.33	49.98	52.24	55.26	57.67	72.14	74.60	77.72	80.41	85.13	87.88	96.20	99.02
BEJ5W1N1	0.059	13.42	13.58	16.68	16.87	18.27	18.48	22.94	23.20	25.06	25.10	29.19	29.35	34.24	34.56
BEJ5W1N2	0.035	9.02	9.02	11.25	11.25	12.35	12.35	15.60	15.60	16.46	16.46	17.75	17.75	19.88	19.88
BEJ5W1S1	0.038	6.99	6.99	8.78	8.78	9.67	9.67	12.32	12.32	13.02	13.02	14.07	14.07	15.81	15.81
BEJ5W2	0.018	5.19	5.19	6.45	6.45	7.07	7.07	8.92	8.92	9.41	9.41	10.14	10.14	11.36	11.36
BEJ5W3	0.038	5.61	6.53	7.30	8.36	8.17	9.28	10.86	12.02	11.58	12.74	12.66	13.83	14.45	15.62
BEJ6	0.128	18.48	18.89	22.97	23.43	25.16	25.68	31.64	33.62	33.36	37.90	35.88	44.19	40.04	54.58
BEJ7	0.081	7.45	7.93	8.82	11.13	9.49	13.98	15.15	23.67	17.42	26.00	20.59	29.57	25.55	34.04
BEJ8	0.06	5.95	6.27	7.06	8.90	7.61	11.72	10.87	18.82	12.50	20.51	14.83	22.66	18.37	25.52
BEJ9	0.019	3.65	3.65	4.58	4.58	5.04	5.04	6.42	6.42	6.79	6.79	7.33	7.33	8.23	8.23
BER1-2	0.873	140.03	149.90	177.91	191.37	196.83	212.14	253.66	273.83	269.25	290.32	293.14	316.26	333.61	365.52
BER2-2W1	0.111	10.64	17.13	14.05	22.12	15.89	24.57	21.75	31.93	23.32	33.87	25.82	36.81	30.02	41.64
BER2-3	0.682	118.93	124.11	150.63	156.69	166.41	172.80	213.19	220.59	225.91	233.55	245.55	254.45	278.40	295.22
BER3-3N1	0.124	23.01	23.13	28.42	28.89	31.08	31.77	39.01	40.39	41.11	42.69	44.24	46.13	49.44	51.86

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
BER3-4	0.528	91.62	96.49	116.46	121.81	128.94	134.26	165.69	171.26	175.88	181.51	191.89	198.99	218.02	233.30
BER3N1-3N2	0.049	3.20	4.72	4.01	6.01	4.43	6.69	5.73	8.73	6.09	9.29	6.66	10.12	7.63	11.52
BER4-4N1	0.011	0.79	0.79	0.93	0.93	1.00	1.00	2.09	2.09	2.40	2.40	2.83	2.83	3.48	3.48
BER4-5	0.455	78.94	82.35	99.65	103.64	110.23	114.20	141.34	145.76	150.12	154.83	164.11	172.53	186.46	202.96
BER5-5S1	0.021	4.66	4.66	5.91	5.91	6.53	6.53	8.37	8.37	8.86	8.86	9.59	9.59	10.80	10.80
BER5-5W1	0.224	39.28	41.07	49.70	51.96	54.94	57.38	72.04	74.57	77.32	79.89	84.72	87.54	96.08	98.98
BER5-6	0.128	18.29	18.70	22.73	23.19	24.87	25.42	31.25	33.56	32.93	37.60	35.44	44.12	39.57	54.33
BER5W1-5W1N1	0.059	13.32	13.49	16.57	16.77	18.15	18.37	22.82	23.09	25.02	25.08	28.95	29.13	33.87	34.20
BER5W1-5W1S1	0.038	6.97	6.97	8.76	8.76	9.65	9.65	12.29	12.29	12.99	12.99	14.04	14.04	15.77	15.77
BER5W1-5W2	0.018	5.15	5.15	6.42	6.42	7.05	7.05	8.91	8.91	9.35	9.35	10.10	10.10	11.30	11.30
BER5W1-5W3	0.038	5.58	6.49	7.27	8.32	8.14	9.24	10.81	11.98	11.52	12.70	12.60	13.78	14.39	15.58
BER5W1N1-5W1N	0.035	9.00	9.00	11.22	11.22	12.32	12.32	15.57	15.57	16.43	16.43	17.71	17.71	19.84	19.84
BER6-7	0.081	7.45	7.93	8.82	11.10	9.49	13.92	15.10	23.61	17.37	26.00	20.58	29.32	25.49	34.01
BER7-8	0.06	5.95	6.27	7.06	8.90	7.61	11.71	10.87	18.82	12.49	20.50	14.83	22.65	18.36	25.52
BER8-9	0.019	3.65	3.65	4.58	4.58	5.04	5.04	6.42	6.42	6.78	6.78	7.33	7.33	8.23	8.23
BO1	0.022	2.40	2.67	3.20	3.52	3.62	3.95	4.92	5.32	5.28	5.69	5.82	6.27	6.75	7.24
BO2	0.029	4.42	5.10	5.75	6.52	6.44	7.23	8.54	9.35	9.10	9.91	9.94	10.75	11.33	12.14
BO3	0.012	2.13	2.34	2.72	2.94	3.01	3.23	3.91	4.12	4.15	4.35	4.50	4.70	5.09	5.28
BO3S1	0.013	2.18	2.44	2.77	3.06	3.07	3.37	3.98	4.29	4.23	4.53	4.59	4.90	5.20	5.50
BO4	0.025	3.35	4.77	4.40	5.99	4.94	6.59	6.58	8.39	7.03	8.87	7.71	9.58	8.87	10.76
BO5	0.019	2.32	3.42	2.98	4.30	3.32	4.74	4.37	6.04	4.66	6.39	5.09	6.90	5.83	7.75
BO6	0.023	3.76	4.54	4.83	5.70	5.38	6.27	7.08	7.98	7.53	8.43	8.22	9.10	9.37	10.22
BO7	0.014	1.89	1.89	2.43	2.43	2.71	2.71	3.56	3.56	3.79	3.79	4.14	4.14	4.74	4.74
BO8	0.028	2.98	4.79	3.97	6.14	4.48	6.81	6.08	8.81	6.53	9.34	7.20	10.13	8.35	11.45
BOJ1	0.184	24.99	31.59	32.48	40.12	36.32	44.39	48.15	57.21	51.38	60.63	56.24	65.76	64.44	74.27
BOJ2	0.162	22.60	28.92	29.32	36.63	32.76	40.47	43.32	51.97	46.19	55.01	50.52	59.58	57.79	67.15
BOJ3	0.134	18.33	24.03	23.74	30.34	26.52	33.48	35.05	42.90	37.38	45.40	40.89	49.14	46.81	55.35
BOJ3S1	0.013	2.18	2.44	2.77	3.06	3.07	3.37	3.98	4.29	4.23	4.53	4.59	4.90	5.20	5.50
BOJ4	0.108	14.07	19.29	18.31	24.38	20.50	26.93	27.25	34.54	29.10	36.56	31.90	39.59	36.63	44.63
BOJ5	0.083	10.80	14.55	14.02	18.43	15.67	20.37	20.78	26.18	22.18	27.73	24.29	30.05	27.87	33.91
BOJ6	0.064	8.51	11.17	11.04	14.18	12.36	15.69	16.47	20.21	17.59	21.42	19.28	23.23	22.14	26.23
BOJ7	0.042	4.87	6.67	6.38	8.54	7.17	9.47	9.61	12.30	10.28	13.06	11.31	14.20	13.06	16.10
BOJ8	0.028	2.98	4.79	3.97	6.14	4.48	6.81	6.08	8.81	6.53	9.34	7.20	10.13	8.35	11.45
BOR1-2	0.162	22.59	28.91	29.28	36.60	32.70	40.44	43.24	51.90	46.10	54.94	50.42	59.48	57.68	67.03
BOR2-3	0.134	18.33	23.96	23.71	30.26	26.47	33.39	34.97	42.77	37.29	45.26	40.79	48.99	46.69	55.17
BOR3-3S1	0.013	2.17	2.42	2.76	3.04	3.06	3.35	3.98	4.27	4.22	4.51	4.58	4.88	5.19	5.48
BOR3-4	0.108	14.07	19.27	18.31	24.36	20.49	26.90	27.23	34.51	29.08	36.53	31.88	39.56	36.62	44.59
BOR4-5	0.083	10.79	14.52	14.01	18.40	15.66	20.34	20.76	26.15	22.15	27.70	24.27	30.01	27.85	33.87
BOR5-6	0.064	8.47	11.12	11.04	14.12	12.36	15.63	16.44	20.14	17.56	21.35	19.25	23.15	22.11	26.15
BOR6-7	0.042	4.86	6.65	6.37	8.51	7.15	9.45	9.60	12.27	10.28	13.03	11.31	14.17	13.06	16.06
BOR7-8	0.028	2.98	4.78	3.95	6.13	4.46	6.80	6.06	8.80	6.50	9.33	7.18	10.12	8.34	11.44
CS1	0.003	0.49	0.49	0.62	0.62	0.68	0.68	0.87	0.87	0.92	0.92	0.99	0.99	1.11	1.11
CS2	0.026	4.25	4.35	5.45	5.57	6.05	6.18	7.84	8.01	8.32	8.50	9.03	9.22	10.20	10.42
CS2N1	0.025	4.40	6.47	5.63	8.14	6.24	8.96	8.07	11.43	8.56	12.08	9.28	13.06	10.48	14.68

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
CS3	0.009	1.68	1.84	2.14	2.31	2.38	2.54	3.08	3.23	3.26	3.41	3.54	3.68	4.00	4.13
CS4	0.027	4.00	4.53	5.21	5.81	5.83	6.45	7.74	8.37	8.25	8.87	9.02	9.63	10.30	10.88
CSJ1	0.089	14.67	16.54	18.87	21.08	20.98	23.36	27.37	30.13	29.06	31.93	31.60	34.59	35.81	39.02
CSJ2	0.086	14.21	16.16	18.29	20.60	20.34	22.81	26.53	29.41	28.18	31.15	30.64	33.74	34.72	38.06
CSJ2N1	0.025	4.40	6.47	5.63	8.14	6.24	8.96	8.07	11.43	8.56	12.08	9.28	13.06	10.48	14.68
CSJ3	0.036	5.60	6.30	7.26	8.03	8.11	8.90	10.70	11.47	11.39	12.15	12.42	13.17	14.14	14.86
CSJ4	0.027	4.00	4.53	5.21	5.81	5.83	6.45	7.74	8.37	8.25	8.87	9.02	9.63	10.30	10.88
CSR1-2	0.086	14.18	16.06	18.25	20.49	20.30	22.70	26.50	29.29	28.15	31.05	30.61	33.64	34.70	37.95
CSR2-2N1	0.025	4.39	6.43	5.61	8.09	6.22	8.92	8.04	11.31	8.53	12.00	9.24	12.98	10.45	14.57
CSR2-3	0.036	5.59	6.29	7.25	8.01	8.09	8.88	10.67	11.44	11.36	12.13	12.39	13.14	14.11	14.83
CSR3-4	0.027	4.00	4.53	5.20	5.81	5.82	6.45	7.73	8.36	8.25	8.86	9.01	9.62	10.29	10.87
DO1	0.008	1.53	1.53	1.93	1.93	2.12	2.12	2.70	2.70	2.85	2.85	3.08	3.08	3.46	3.46
DO1N	0.025	1.81	3.12	2.35	4.02	2.62	4.47	3.49	5.85	3.73	6.21	4.10	6.76	4.75	7.68
DO2	0.019	3.36	3.68	4.28	4.62	4.74	5.09	6.15	6.48	6.53	6.84	7.09	7.39	8.01	8.30
DO2S	0.021	2.80	3.25	3.64	4.18	4.08	4.64	5.43	6.03	5.79	6.40	6.34	6.95	7.24	7.86
DO3	0.039	5.97	6.62	7.54	8.31	8.35	9.15	10.84	11.68	11.50	12.35	12.50	13.35	14.15	15.01
DO3N	0.011	1.40	1.60	1.82	2.06	2.03	2.29	2.71	2.98	2.89	3.16	3.17	3.43	3.62	3.89
DOJ1	0.123	16.49	19.37	21.00	24.57	23.31	27.17	30.37	34.98	32.26	37.05	35.10	40.15	39.84	45.28
DOJ2	0.089	13.40	15.04	17.13	19.03	19.05	21.02	24.93	26.98	26.50	28.55	28.86	30.91	32.78	34.82
DOJ3	0.049	7.37	8.22	9.36	10.37	10.39	11.44	13.55	14.66	14.39	15.51	15.66	16.78	17.77	18.90
DOR1-2	0.089	13.38	15.02	17.10	19.01	19.01	21.00	24.89	26.95	26.46	28.52	28.81	30.88	32.73	34.79
DOR2-3	0.049	7.35	8.20	9.36	10.35	10.38	11.42	13.55	14.63	14.39	15.48	15.66	16.75	17.77	18.86
FN1	0.049	4.16	4.16	4.96	4.96	5.37	5.37	6.65	6.65	7.00	7.00	7.53	7.53	8.42	8.42
FN2	0.015	1.56	1.93	1.92	2.40	2.10	2.63	2.66	3.35	2.81	3.54	3.03	3.84	3.41	4.32
FN3	0.022	1.53	1.42	1.95	1.83	2.16	2.04	2.84	2.69	3.03	2.87	3.32	3.15	3.82	3.62
FN4	0.017	3.01	3.06	3.78	3.85	4.16	4.24	5.31	5.40	5.61	5.71	6.07	6.17	6.82	6.93
FN4N	0.017	2.91	3.22	3.70	4.04	4.10	4.45	5.32	5.67	5.65	5.99	6.13	6.47	6.94	7.26
FN5	0.009	2.43	2.43	3.02	3.02	3.31	3.31	4.17	4.17	4.40	4.40	4.74	4.74	5.31	5.31
FN6	0.029	2.93	3.39	4.00	4.55	4.55	5.15	6.25	7.02	6.72	7.54	7.44	8.32	8.67	9.65
FN7	0.04	2.26	2.26	2.95	2.96	3.33	3.34	4.46	4.48	4.77	4.79	5.24	5.27	6.04	6.07
FN8	0.038	5.58	5.63	7.26	7.32	8.12	8.19	10.79	10.89	11.51	11.61	12.58	12.69	14.36	14.49
FN9	0.052	4.60	6.26	6.11	8.23	6.90	9.25	9.38	12.44	10.08	13.32	11.14	14.67	12.94	16.94
FNA	0.065	6.76	6.52	8.82	8.63	9.90	9.73	13.25	13.18	14.19	14.14	15.64	15.59	18.08	18.08
FNA-R	0.065	3.93	3.81	4.46	4.34	4.72	4.58	11.66	10.40	13.36	12.24	15.60	14.77	18.88	17.65
FNJ1	1.042	111.88	122.15	141.79	154.65	156.87	171.00	202.85	220.41	215.32	233.65	234.06	253.51	265.54	286.70
FNJ2-ARJ1	0.994	107.97	118.39	137.38	150.30	152.20	166.38	197.59	214.99	209.92	228.06	228.42	247.66	259.55	280.45
FNJ3-RWJ1	0.564	63.93	69.91	81.46	88.82	90.34	98.39	117.42	127.20	124.80	134.95	135.86	146.59	156.01	166.00
FNJ4	0.267	24.82	27.46	31.77	35.11	35.27	38.96	45.99	50.75	48.92	53.96	55.35	58.77	68.81	72.03
FNJ5	0.233	19.14	21.38	24.58	27.44	27.32	30.52	35.79	40.04	39.31	42.63	46.40	48.38	57.36	60.33
FNJ6	0.224	17.83	20.04	22.91	25.73	25.48	28.64	33.52	37.63	38.10	40.09	44.84	46.79	55.47	58.48
FNJ7	0.196	15.21	16.96	19.30	21.53	21.39	23.85	30.16	30.99	34.04	34.64	39.69	41.07	48.77	51.17
FNJ8	0.155	13.00	14.75	16.52	18.79	18.30	20.82	25.76	27.12	29.61	30.41	34.94	36.36	43.30	45.60
FNJ9	0.117	7.80	9.28	9.63	11.59	10.60	12.78	18.74	18.95	21.45	22.25	25.15	26.58	30.97	33.31
FNJA	0.065	3.93	3.81	4.46	4.34	4.72	4.58	11.66	10.40	13.36	12.24	15.60	14.77	18.88	17.65

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
FNR1-2	0.994	107.94	118.21	137.28	150.14	152.09	166.22	197.34	214.90	209.64	227.97	228.13	247.57	259.19	280.36
FNR2-3	0.564	63.84	69.63	81.41	88.53	90.27	98.02	117.40	126.78	124.77	134.53	135.84	146.15	155.91	165.56
FNR3-4	0.267	24.77	27.42	31.71	34.99	35.18	38.88	45.90	50.63	48.86	53.83	55.23	58.65	68.31	71.57
FNR4-5	0.233	19.11	21.37	24.52	27.45	27.27	30.52	35.76	39.99	39.00	42.59	46.01	47.98	57.35	60.31
FNR5-6	0.224	17.83	20.02	22.88	25.71	25.47	28.61	33.50	37.58	37.94	40.04	44.71	46.68	55.17	58.11
FNR6-7	0.196	15.19	16.91	19.28	21.48	21.36	23.79	29.87	30.95	33.92	34.63	39.64	41.02	48.28	50.61
FNR7-8	0.155	12.98	14.73	16.49	18.76	18.27	20.79	25.77	27.07	29.31	29.89	34.44	35.81	42.95	45.30
FNR8-9	0.117	7.79	9.27	9.63	11.59	10.59	12.77	18.72	18.89	21.32	22.14	25.03	26.46	30.59	32.87
FNR9-A	0.065	3.93	3.81	4.46	4.34	4.72	4.57	11.41	10.18	13.00	11.91	15.08	14.23	18.25	17.53
FR1	0.002	0.19	0.39	0.25	0.49	0.28	0.54	0.38	0.69	0.41	0.73	0.45	0.79	0.52	0.89
FR1S1	0.014	2.49	3.08	3.21	3.86	3.58	4.24	4.71	5.39	5.02	5.69	5.47	6.15	6.23	6.90
FR1S2	0.046	6.68	8.24	8.50	10.35	9.44	11.40	12.34	14.53	13.13	15.36	14.34	16.60	16.34	18.65
FR1S3	0.051	6.27	8.25	8.25	10.58	9.28	11.75	12.49	15.26	13.38	16.18	14.74	17.57	17.01	19.87
FR2	0.027	3.60	6.85	4.86	8.63	5.51	9.51	7.53	12.14	8.09	12.84	8.92	13.88	10.34	15.61
FR3	0.074	4.24	4.53	5.25	5.66	5.78	6.24	7.40	8.02	7.84	8.51	8.51	9.26	9.65	10.56
FR3N1	0.017	0.94	0.94	1.23	1.23	1.40	1.40	1.88	1.88	2.01	2.01	2.21	2.21	2.55	2.55
FR3S	0.035	2.25	3.01	2.85	3.87	3.15	4.32	4.08	5.71	4.35	6.11	4.74	6.72	5.44	7.75
FR3S1	0.046	2.64	2.96	3.33	3.81	3.69	4.25	4.78	5.59	5.08	5.96	5.54	6.52	6.31	7.49
FR3S2	0.017	2.26	2.60	2.94	3.34	3.30	3.71	4.39	4.81	4.68	5.11	5.12	5.55	5.85	6.27
FR3S2-R	0.017	1.20	1.35	1.47	1.60	1.57	2.48	3.61	4.39	4.09	4.84	4.75	5.43	5.75	6.24
FR4	0.076	4.25	4.25	5.29	5.29	5.87	5.87	7.63	7.63	8.12	8.12	8.85	8.85	10.09	10.09
FR5	0.093	5.23	5.23	6.27	6.27	6.85	6.85	8.70	8.70	9.21	9.21	9.99	9.99	11.31	11.31
FRJ1S1	0.112	15.16	19.29	19.60	24.45	21.89	27.04	29.03	34.74	30.99	36.78	33.97	39.84	38.95	44.88
FRJ1S2	0.097	12.93	16.48	16.71	20.91	18.65	23.14	24.74	29.77	26.42	31.53	28.97	34.15	33.24	38.50
FRJ1S3	0.051	6.27	8.25	8.25	10.58	9.28	11.75	12.49	15.26	13.38	16.18	14.74	17.57	17.01	19.87
FRJ2	0.494	29.80	31.37	36.89	39.22	40.59	43.25	53.92	58.01	57.36	61.57	62.43	66.96	71.12	76.12
FRJ3	0.467	27.93	29.30	34.69	36.60	38.21	40.67	50.63	54.04	53.73	57.39	58.40	62.44	66.49	71.17
FRJ3N1	0.017	0.94	0.94	1.23	1.23	1.40	1.40	1.88	1.88	2.01	2.01	2.21	2.21	2.55	2.55
FRJ3S1	0.063	3.80	4.24	4.77	5.34	5.24	6.60	8.24	9.76	8.85	10.38	9.69	11.30	10.98	12.85
FRJ3S2	0.017	1.20	1.35	1.47	1.60	1.57	2.48	3.61	4.39	4.09	4.84	4.75	5.43	5.75	6.24
FRJ4	0.278	16.83	16.83	20.83	20.83	22.90	22.90	29.37	29.37	31.16	31.16	33.86	33.86	38.59	38.59
FRJ5-STJ1	0.202	12.59	12.59	15.61	15.61	17.16	17.16	21.98	21.98	23.31	23.31	25.32	25.32	28.81	28.81
FRJ6	0.093	5.23	5.23	6.27	6.27	6.85	6.85	8.70	8.70	9.21	9.21	9.99	9.99	11.31	11.31
FRR1-1S1	0.112	15.15	19.28	19.59	24.45	21.88	27.04	29.02	34.74	30.99	36.78	33.96	39.83	38.94	44.88
FRR1-2	0.494	29.79	31.36	36.89	39.22	40.58	43.23	53.88	58.00	57.35	61.57	62.43	66.95	71.10	76.12
FRR1S1-1S2	0.097	12.86	16.42	16.67	20.86	18.64	23.08	24.74	29.71	26.42	31.47	28.97	34.09	33.24	38.44
FRR1S2-1S3	0.051	6.25	8.25	8.20	10.57	9.24	11.75	12.45	15.25	13.34	16.18	14.69	17.57	16.95	19.87
FRR2-3	0.467	27.92	29.29	34.68	36.59	38.21	40.63	50.61	54.02	53.72	57.36	58.40	62.43	66.48	71.13
FRR3-3N1	0.017	0.94	0.94	1.23	1.23	1.39	1.39	1.88	1.88	2.01	2.01	2.21	2.21	2.55	2.55
FRR3-3S1	0.063	3.80	4.24	4.77	5.34	5.24	6.57	8.25	9.75	8.84	10.38	9.69	11.30	10.98	12.84
FRR3-4	0.278	16.83	16.83	20.82	20.82	22.90	22.90	29.36	29.36	31.15	31.15	33.86	33.86	38.59	38.59
FRR3S1-3S2	0.017	1.20	1.35	1.47	1.60	1.57	2.47	3.64	4.41	4.07	4.82	4.74	5.41	5.71	6.24
FRR4-5	0.202	12.58	12.58	15.62	15.62	17.15	17.15	21.98	21.98	23.30	23.30	25.31	25.31	28.80	28.80
FRR5-6	0.093	5.23	5.23	6.27	6.27	6.85	6.85	8.70	8.70	9.21	9.21	9.99	9.99	11.31	11.31

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
FR-SL1	0.947	91.12	101.29	114.27	126.73	125.97	139.31	161.34	180.23	170.89	192.39	187.63	210.95	220.34	242.26
GS1	0.01	1.47	1.70	1.91	2.18	2.13	2.42	2.84	3.14	3.02	3.33	3.30	3.61	3.77	4.08
GS2	0.016	2.10	2.10	2.70	2.70	3.00	3.01	3.92	3.92	4.16	4.17	4.53	4.53	5.13	5.14
GS3	0.009	2.55	2.55	3.17	3.17	3.48	3.48	4.39	4.39	4.63	4.63	4.99	4.99	5.58	5.58
GS3N1	0.028	5.32	5.32	6.68	6.68	7.36	7.36	9.37	9.37	9.91	9.91	10.70	10.70	12.02	12.02
GS4	0.033	5.50	4.85	7.04	6.31	7.81	7.06	10.13	9.38	10.74	10.00	11.65	10.93	13.17	12.47
GS4S1	0.012	2.01	2.05	2.58	2.62	2.86	2.91	3.70	3.76	3.92	3.98	4.25	4.32	4.80	4.88
GS5	0.033	5.84	5.84	7.33	7.33	8.08	8.08	10.30	10.30	10.89	10.89	11.77	11.77	13.23	13.23
GSJ2	0.13	22.25	21.63	28.21	27.52	31.18	30.48	40.06	39.38	42.41	41.74	45.92	45.28	51.75	51.15
GSJ3	0.114	20.35	19.73	25.76	25.07	28.46	27.75	36.51	35.81	38.64	37.95	41.82	41.15	47.09	46.46
GSJ3N1	0.028	5.32	5.32	6.68	6.68	7.36	7.36	9.37	9.37	9.91	9.91	10.70	10.70	12.02	12.02
GSJ4	0.077	13.28	12.66	16.87	16.18	18.67	17.96	24.03	23.34	25.45	24.77	27.58	26.91	31.09	30.45
GSJ4S1	0.012	2.01	2.05	2.58	2.62	2.86	2.91	3.70	3.76	3.92	3.98	4.25	4.32	4.80	4.88
GSJ5	0.033	5.84	5.84	7.33	7.33	8.08	8.08	10.30	10.30	10.89	10.89	11.77	11.77	13.23	13.23
GSR1-2	0.13	22.24	21.63	28.20	27.52	31.18	30.48	40.05	39.38	42.40	41.74	45.92	45.27	51.74	51.13
GSR2-3	0.114	20.25	19.64	25.66	24.97	28.35	27.64	36.39	35.69	38.51	37.83	41.69	41.03	46.96	46.32
GSR3-3N1	0.028	5.30	5.30	6.65	6.65	7.33	7.33	9.33	9.33	9.86	9.86	10.65	10.65	11.96	11.96
GSR3-4	0.077	13.26	12.64	16.85	16.16	18.65	17.94	24.01	23.31	25.42	24.74	27.55	26.88	31.06	30.42
GSR4-4S1	0.012	2.01	2.04	2.58	2.62	2.86	2.90	3.70	3.75	3.92	3.98	4.25	4.31	4.80	4.87
GSR4-5	0.033	5.83	5.83	7.33	7.33	8.07	8.07	10.30	10.30	10.88	10.88	11.76	11.76	13.22	13.22
HE1	0.022	1.23	1.39	1.47	1.89	1.61	2.14	2.17	2.92	2.33	3.13	2.56	3.46	2.95	4.02
HE2	0.03	3.92	4.64	5.09	5.95	5.70	6.62	7.60	8.60	8.11	9.12	8.87	9.91	10.15	11.21
HE3	0.073	4.11	4.11	4.92	4.92	5.33	5.33	6.55	6.55	6.87	6.87	7.31	7.31	8.04	8.04
HE4	0.04	2.65	3.77	3.80	5.09	4.38	5.77	6.17	7.89	6.67	8.49	7.43	9.38	8.73	10.92
HE5	0.023	1.36	1.36	2.05	2.05	2.40	2.40	3.48	3.48	3.78	3.78	4.24	4.24	5.01	5.01
HEJ1	0.187	13.05	15.03	17.09	19.59	19.15	21.92	25.52	29.00	27.25	30.92	29.78	33.73	33.98	38.43
HEJ2	0.165	11.84	13.66	15.65	17.74	17.58	19.82	23.52	26.16	25.14	27.88	27.49	30.39	31.40	34.57
HEJ3	0.135	8.09	9.18	10.69	11.97	12.02	13.41	16.09	17.81	17.20	19.02	18.81	20.76	21.48	23.69
HEJ4	0.062	4.01	5.13	5.85	7.14	6.78	8.18	9.65	11.38	10.45	12.27	11.65	13.62	13.68	15.93
HEJ5	0.023	1.36	1.36	2.05	2.05	2.40	2.40	3.48	3.48	3.78	3.78	4.24	4.24	5.01	5.01
HER1-2	0.165	11.83	13.65	15.63	17.73	17.57	19.81	23.50	26.15	25.12	27.87	27.47	30.37	31.37	34.55
HER2-3	0.135	8.09	9.15	10.69	11.94	12.01	13.37	16.05	17.77	17.16	18.97	18.77	20.71	21.44	23.62
HER3-4	0.062	4.01	5.12	5.84	7.11	6.77	8.15	9.63	11.36	10.43	12.24	11.64	13.59	13.70	15.91
HER4-5	0.023	1.36	1.36	2.05	2.05	2.40	2.40	3.48	3.48	3.78	3.78	4.23	4.23	5.01	5.01
HS1	0.018	3.25	2.97	4.08	3.77	4.49	4.18	5.72	5.43	6.05	5.76	6.54	6.25	7.34	7.07
HS2	0.019	3.02	3.02	3.86	3.86	4.30	4.30	5.63	5.63	6.00	6.00	6.55	6.55	7.46	7.46
HS3	0.051	8.38	7.18	10.52	9.12	11.59	10.12	14.79	13.20	15.64	14.05	16.92	15.33	19.02	17.47
HSJ1	0.088	14.48	13.08	18.28	16.63	20.19	18.45	25.94	24.05	27.47	25.58	29.76	27.89	33.57	31.74
HSJ2	0.071	11.27	10.14	14.25	12.90	15.75	14.31	20.27	18.69	21.48	19.89	23.29	21.70	26.30	24.74
HSJ3	0.051	8.38	7.18	10.52	9.12	11.59	10.12	14.79	13.20	15.64	14.05	16.92	15.33	19.02	17.47
HSR1	0.088	14.45	13.06	18.24	16.59	20.15	18.41	25.89	24.01	27.42	25.53	29.71	27.84	33.52	31.69
HSR1-2	0.071	11.26	10.13	14.24	12.87	15.74	14.28	20.27	18.68	21.48	19.88	23.29	21.70	26.29	24.74
HSR2-3	0.051	8.37	7.18	10.51	9.12	11.58	10.12	14.79	13.19	15.64	14.04	16.91	15.32	19.02	17.46
MC1	0.017	2.81	3.32	3.73	4.32	4.20	4.83	5.64	6.33	6.03	6.73	6.62	7.32	7.59	8.31

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
MC2	0.019	5.16	5.16	6.43	6.43	7.05	7.05	8.90	8.90	9.39	9.39	10.12	10.12	11.33	11.33
MC2S	0.021	5.97	5.97	7.42	7.42	8.13	8.13	10.26	10.26	10.82	10.82	11.66	11.66	13.05	13.05
MC3	0.028	5.45	5.45	7.07	7.07	7.89	7.89	10.40	10.40	11.07	11.07	12.07	12.07	13.72	13.72
MC3N	0.017	3.10	3.10	3.97	3.97	4.40	4.40	5.68	5.68	6.02	6.02	6.52	6.52	7.36	7.36
MC3W1	0.036	6.33	6.94	8.06	8.72	8.94	9.60	11.60	12.22	12.31	12.91	13.36	13.95	15.11	15.66
MC3W2	0.04	3.70	3.70	4.43	4.43	4.79	4.79	6.06	6.06	6.46	6.46	7.08	7.08	8.11	8.11
MC3W3	0.036	4.98	4.64	6.39	6.03	7.12	6.74	9.39	8.91	10.02	9.52	10.96	10.44	12.55	11.99
MC4	0.019	1.73	1.73	2.07	2.07	2.24	2.24	2.75	2.75	2.90	2.90	3.12	3.12	3.51	3.51
MC5	0.038	2.62	2.62	3.89	3.89	4.52	4.52	6.51	6.51	7.06	7.06	7.88	7.88	9.28	9.28
MC6	0.015	2.82	2.82	3.54	3.54	3.90	3.90	4.97	4.97	5.25	5.25	5.67	5.67	6.37	6.37
MC7	0.035	3.25	3.25	3.89	3.89	4.24	4.24	5.59	5.59	5.96	5.96	6.51	6.51	7.44	7.44
MC8	0.034	5.52	5.52	7.08	7.08	7.87	7.87	10.21	10.21	10.83	10.83	11.76	11.76	13.30	13.30
MCJ1	0.355	49.07	49.88	62.66	63.53	69.52	70.37	90.19	90.89	95.66	96.33	103.93	104.54	117.69	118.21
MCJ2	0.339	46.59	46.93	59.28	59.67	65.68	66.05	85.02	85.21	90.13	90.29	97.88	97.99	110.76	110.78
MCJ3	0.299	38.25	38.55	48.90	49.24	54.27	54.59	70.65	70.81	75.06	75.19	81.68	81.76	92.72	92.72
MCJ3W1	0.112	14.91	15.20	18.73	19.06	20.68	20.98	26.70	26.85	28.35	28.46	30.83	30.90	34.98	34.98
MCJ3W2	0.076	8.66	8.32	10.81	10.43	11.89	11.51	15.31	14.84	16.29	15.78	17.77	17.24	20.26	19.70
MCJ3W3	0.036	4.98	4.64	6.39	6.03	7.12	6.74	9.39	8.91	10.02	9.52	10.96	10.44	12.55	11.99
MCJ4	0.141	15.85	15.85	20.35	20.35	22.61	22.61	29.50	29.50	31.37	31.37	34.15	34.15	38.83	38.83
MCJ5	0.122	14.15	14.15	18.30	18.30	20.38	20.38	26.87	26.87	28.63	28.63	31.27	31.27	35.70	35.70
MCJ6	0.085	11.55	11.55	14.46	14.46	15.93	15.93	20.48	20.48	21.69	21.69	23.50	23.50	26.51	26.51
MCJ7	0.07	8.76	8.76	10.96	10.96	12.08	12.08	15.57	15.57	16.51	16.51	17.91	17.91	20.23	20.23
MCJ8	0.034	5.52	5.52	7.08	7.08	7.87	7.87	10.21	10.21	10.83	10.83	11.76	11.76	13.30	13.30
MCR1-2	0.339	46.53	46.85	59.27	59.63	65.68	66.02	84.98	85.18	90.09	90.25	97.81	97.92	110.66	110.68
MCR2-3	0.299	38.21	38.50	48.88	49.19	54.26	54.55	70.64	70.80	75.04	75.17	81.64	81.73	92.66	92.67
MCR3-3W1	0.112	14.87	15.16	18.72	19.02	20.67	20.95	26.68	26.84	28.32	28.44	30.78	30.86	34.91	34.91
MCR3-4	0.141	15.84	15.84	20.30	20.30	22.55	22.55	29.47	29.47	31.33	31.33	34.12	34.12	38.83	38.83
MCR3W1-3W2	0.076	8.65	8.31	10.80	10.43	11.89	11.50	15.31	14.83	16.29	15.78	17.77	17.24	20.26	19.70
MCR3W2-3W3	0.036	4.96	4.62	6.39	6.01	7.12	6.73	9.37	8.90	9.99	9.50	10.93	10.42	12.51	11.96
MCR4-5	0.122	14.11	14.11	18.29	18.29	20.38	20.38	26.80	26.80	28.57	28.57	31.18	31.18	35.55	35.55
MCR5-6	0.085	11.55	11.55	14.46	14.46	15.93	15.93	20.45	20.45	21.66	21.66	23.46	23.46	26.46	26.46
MCR6-7	0.07	8.76	8.76	10.96	10.96	12.07	12.07	15.56	15.56	16.49	16.49	17.89	17.89	20.22	20.22
MCR7-8	0.034	5.52	5.52	7.08	7.08	7.86	7.86	10.20	10.20	10.82	10.82	11.75	11.75	13.29	13.29
MX1	0.01	0.58	0.58	0.69	0.69	0.75	0.76	0.96	1.00	1.02	1.07	1.12	1.17	1.28	1.34
MX1N1	0.018	2.29	1.95	2.90	2.54	3.22	2.84	4.19	3.77	4.46	4.02	4.86	4.40	5.55	5.05
MX2	0.03	4.77	5.40	6.20	6.91	6.94	7.66	9.20	9.90	9.80	10.50	10.71	11.39	12.20	12.86
MX3	0.018	2.97	3.37	3.77	4.23	4.18	4.66	5.42	5.94	5.75	6.28	6.25	6.78	7.07	7.62
MX3S	0.045	4.56	7.04	5.86	9.04	6.54	10.05	8.71	13.05	9.30	13.84	10.20	15.03	11.70	17.00
MX3S1	0.033	1.86	1.86	2.23	2.23	2.41	2.41	2.96	2.96	3.11	3.11	3.47	3.47	4.15	4.15
MX3S2	0.015	0.86	0.86	1.03	1.03	1.11	1.11	1.37	1.37	1.44	1.44	1.57	1.57	1.82	1.82
MX4	0.01	1.52	1.79	1.97	2.29	2.21	2.54	2.93	3.28	3.13	3.48	3.42	3.77	3.90	4.26
MX5	0.029	2.67	2.67	3.19	3.19	3.45	3.45	4.24	4.24	4.45	4.45	4.85	4.85	5.58	5.59
MXJ1	0.209	20.92	25.14	26.44	31.68	29.26	34.96	37.98	44.80	40.34	47.41	43.99	51.40	50.24	58.06
MXJ1N1	0.018	2.29	1.95	2.90	2.54	3.22	2.84	4.19	3.77	4.46	4.02	4.86	4.40	5.55	5.05

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
MXJ2	0.181	18.07	22.63	22.87	28.48	25.32	31.39	32.92	40.17	34.98	42.49	38.17	46.05	43.56	51.98
MXJ3	0.15	13.90	17.42	17.38	21.81	19.16	24.00	24.70	30.57	26.20	32.31	28.66	35.02	32.88	39.58
MXJ3S1	0.048	2.72	2.72	3.25	3.25	3.52	3.52	4.33	4.33	4.55	4.55	5.03	5.03	5.94	5.94
MXJ3S2	0.015	0.86	0.86	1.03	1.03	1.11	1.11	1.37	1.37	1.44	1.44	1.57	1.57	1.82	1.82
MXJ4	0.039	4.14	4.40	5.12	5.42	5.62	5.93	7.12	7.45	7.52	7.85	8.15	8.47	9.22	9.53
MXJ5	0.029	2.67	2.67	3.19	3.19	3.45	3.45	4.24	4.24	4.45	4.45	4.85	4.85	5.58	5.59
MXR1-1N1	0.018	2.29	1.95	2.90	2.54	3.21	2.84	4.19	3.77	4.46	4.02	4.86	4.40	5.55	5.04
MXR1-2	0.181	18.06	22.63	22.86	28.47	25.32	31.39	32.92	40.16	34.97	42.49	38.16	46.04	43.56	51.98
MXR2-3	0.15	13.89	17.39	17.38	21.76	19.16	23.94	24.70	30.52	26.19	32.26	28.63	34.95	32.86	39.45
MXR3-3S1	0.048	2.72	2.72	3.25	3.25	3.52	3.52	4.33	4.33	4.55	4.55	5.03	5.03	5.94	5.94
MXR3-4	0.039	4.14	4.39	5.12	5.41	5.61	5.91	7.11	7.43	7.52	7.83	8.14	8.46	9.21	9.52
MXR3S1-3S2	0.015	0.86	0.86	1.03	1.03	1.11	1.11	1.37	1.37	1.44	1.44	1.57	1.57	1.82	1.82
MXR4-5	0.029	2.67	2.67	3.19	3.19	3.45	3.45	4.24	4.24	4.45	4.45	4.85	4.85	5.58	5.59
MY1	0.039	2.21	2.21	2.64	2.64	2.86	2.86	3.52	3.52	3.68	3.69	3.94	3.95	4.41	4.40
MY2	0.012	1.20	1.20	1.52	1.52	1.68	1.68	2.17	2.17	2.30	2.30	2.51	2.51	2.85	2.85
MY2N	0.042	4.36	4.36	5.78	5.78	6.51	6.51	8.83	8.83	9.47	9.47	10.46	10.46	12.13	12.13
MY3	0.053	6.82	7.39	8.50	9.24	9.36	10.17	12.06	12.98	12.79	13.74	13.89	14.86	15.73	16.74
MY4	0.082	7.04	8.80	9.35	11.48	10.55	12.88	14.30	17.30	15.35	18.53	16.94	20.43	19.68	23.60
MY4N1	0.048	7.35	7.35	9.44	9.44	10.50	10.50	13.65	13.65	14.48	14.48	15.74	15.74	17.81	17.81
MY4S1	0.042	7.61	7.61	9.55	9.55	10.52	10.52	13.42	13.42	14.18	14.18	15.33	15.33	17.22	17.22
MY4S2	0.042	4.13	6.06	5.12	7.58	5.62	8.35	7.14	10.66	7.56	11.28	8.19	12.20	9.24	13.74
MY4S3	0.027	3.53	4.64	4.64	5.94	5.22	6.59	7.03	8.54	7.53	9.05	8.29	9.82	9.55	11.10
MY4S3-R	0.027	1.99	2.37	2.35	3.91	2.49	5.19	5.67	8.28	6.44	8.94	7.65	9.77	9.40	11.04
MY5	0.037	5.83	5.83	7.49	7.49	8.32	8.32	10.80	10.80	11.46	11.46	12.45	12.45	14.08	14.08
MY6	0.056	8.80	8.89	11.14	11.27	12.34	12.48	16.01	16.20	16.99	17.19	18.46	18.67	20.90	21.14
MYJ1	0.48	55.66	60.32	70.66	76.77	78.28	85.08	101.43	114.89	107.78	122.55	119.58	133.96	138.57	152.10
MYJ2	0.44	53.58	58.28	68.19	74.31	75.62	82.41	98.16	111.45	104.23	119.30	115.73	130.30	134.44	148.02
MYJ3	0.387	48.24	52.97	61.17	67.29	67.72	74.49	87.49	101.07	92.80	108.00	103.43	117.61	120.03	133.30
MYJ4	0.334	41.77	45.88	53.09	58.43	58.80	64.73	75.96	88.52	80.54	94.64	89.91	103.48	104.97	117.43
MYJ4S1	0.111	12.87	15.25	15.85	18.97	17.34	21.73	23.67	31.52	25.93	33.61	28.97	36.56	33.58	41.18
MYJ4S2	0.069	6.07	8.24	7.42	10.74	8.03	13.17	12.70	18.77	13.78	19.90	15.21	21.59	17.29	24.34
MYJ4S3	0.027	1.99	2.37	2.35	3.91	2.49	5.19	5.67	8.28	6.44	8.94	7.65	9.77	9.40	11.04
MYJ5	0.141	21.96	22.05	28.04	28.17	31.11	31.26	40.41	40.61	42.89	43.09	46.59	46.81	52.73	52.98
MYJ5N1	0.048	7.35	7.35	9.44	9.44	10.50	10.50	13.65	13.65	14.48	14.48	15.74	15.74	17.81	17.81
MYJ6	0.056	8.80	8.89	11.14	11.27	12.34	12.48	16.01	16.20	16.99	17.19	18.46	18.67	20.90	21.14
MYR1-2	0.44	53.48	58.15	68.05	74.17	75.46	82.26	97.97	111.40	104.14	118.89	115.69	130.10	134.35	147.88
MYR2-3	0.387	48.20	52.90	61.09	67.22	67.62	74.41	87.36	100.82	92.72	107.72	103.41	117.56	119.88	133.30
MYR3-4	0.334	41.66	45.72	52.93	58.24	58.62	64.53	75.75	88.29	80.35	94.48	89.65	103.18	104.71	117.20
MYR4-4S1	0.111	12.85	15.24	15.85	18.97	17.34	21.70	23.66	31.31	25.82	33.53	28.87	36.50	33.39	41.14
MYR4-5	0.141	21.88	21.96	27.95	28.07	31.02	31.15	40.30	40.46	42.76	42.94	46.45	46.64	52.57	52.79
MYR4S1-4S2	0.069	6.07	8.23	7.41	10.66	8.03	13.16	12.68	18.66	13.76	19.90	15.17	21.57	17.29	24.31
MYR4S2-4S3	0.027	1.99	2.37	2.35	3.85	2.49	5.14	5.57	8.17	6.43	8.88	7.53	9.76	9.26	11.04
MYR5-5N1	0.048	7.35	7.35	9.44	9.44	10.49	10.49	13.64	13.64	14.48	14.48	15.73	15.73	17.80	17.80
MYR5-6	0.056	8.78	8.87	11.11	11.24	12.30	12.45	15.97	16.16	16.95	17.15	18.41	18.64	20.85	21.10

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
RB1	0.007	0.70	1.15	0.88	1.44	0.97	1.59	1.26	2.03	1.33	2.15	1.45	2.32	1.64	2.61
RB2	0.037	7.59	7.69	9.52	9.65	10.48	10.62	13.33	13.50	14.08	14.26	15.21	15.39	17.07	17.27
RB2S1	0.036	5.09	5.82	6.72	7.58	7.56	8.48	10.17	11.22	10.89	11.95	11.97	13.05	13.78	14.87
RB2S2	0.022	2.17	2.19	2.96	2.99	3.36	3.40	4.60	4.66	4.94	5.02	5.47	5.55	6.38	6.47
RB2S3	0.015	2.88	2.88	3.61	3.61	3.98	3.98	5.07	5.07	5.35	5.35	5.78	5.78	6.49	6.49
RB3	0.027	1.78	2.73	2.52	3.73	2.89	4.23	4.05	5.81	4.37	6.25	4.86	6.92	5.68	8.06
RB4	0.035	5.81	5.90	7.45	7.56	8.27	8.39	10.72	10.87	11.37	11.53	12.35	12.51	13.95	14.14
RBJ2	0.172	24.75	26.75	32.09	34.55	35.77	38.48	46.97	50.36	49.99	53.56	54.51	58.35	62.06	66.35
RBJ2S1	0.073	9.98	10.75	13.13	14.03	14.74	15.69	19.66	20.75	21.01	22.11	23.03	24.15	26.43	27.57
RBJ2S2	0.037	5.03	5.05	6.55	6.58	7.31	7.36	9.64	9.71	10.27	10.35	11.23	11.31	12.84	12.94
RBJ2S3	0.015	2.88	2.88	3.61	3.61	3.98	3.98	5.07	5.07	5.35	5.35	5.78	5.78	6.49	6.49
RBJ3	0.062	7.57	8.56	9.93	11.22	11.12	12.54	14.70	16.60	15.66	17.70	17.09	19.36	19.48	22.13
RBJ4	0.035	5.81	5.90	7.45	7.56	8.27	8.39	10.72	10.87	11.37	11.53	12.35	12.51	13.95	14.14
RBR1-2	0.172	24.70	26.62	32.06	34.40	35.76	38.32	46.96	50.19	49.98	53.37	54.50	58.15	62.04	66.13
RBR2-2S1	0.073	9.95	10.71	13.07	13.98	14.67	15.63	19.57	20.67	20.90	22.03	22.93	24.06	26.32	27.48
RBR2-3	0.062	7.55	8.56	9.90	11.19	11.08	12.54	14.66	16.59	15.62	17.69	17.05	19.34	19.45	22.11
RBR2S1-2S2	0.037	5.01	5.03	6.52	6.55	7.29	7.32	9.63	9.68	10.26	10.33	11.22	11.29	12.84	12.92
RBR2S2-2S3	0.015	2.86	2.86	3.59	3.59	3.96	3.96	5.04	5.04	5.33	5.33	5.76	5.76	6.47	6.47
RBR3-4	0.035	5.81	5.87	7.43	7.53	8.26	8.36	10.70	10.83	11.34	11.48	12.32	12.46	13.92	14.08
RW1	0.034	3.42	3.47	4.20	4.30	4.60	4.72	5.81	6.01	6.14	6.36	6.63	6.89	7.46	7.76
RW1S1	0.014	2.41	2.41	3.08	3.08	3.41	3.41	4.41	4.41	4.68	4.68	5.07	5.07	5.73	5.73
RW1S2	0.012	2.33	2.33	2.92	2.92	3.22	3.22	4.09	4.09	4.33	4.33	4.67	4.67	5.25	5.25
RW1W1	0.021	3.94	3.94	4.94	4.94	5.44	5.44	6.93	6.93	7.33	7.33	7.91	7.91	8.89	8.89
RW1W2	0.028	4.51	5.45	5.79	6.84	6.45	7.53	8.47	9.59	9.02	10.13	9.84	10.94	11.22	12.29
RW1W3	0.04	6.87	7.62	8.75	9.57	9.70	10.54	12.59	13.42	13.35	14.18	14.50	15.32	16.40	17.20
RW2	0.018	2.18	2.90	2.86	3.71	3.22	4.12	4.34	5.35	4.65	5.67	5.12	6.16	5.91	6.96
RW3	0.008	0.78	0.67	1.02	0.91	1.15	1.04	1.55	1.43	1.66	1.54	1.83	1.70	2.13	1.98
RW4	0.032	3.10	4.04	4.02	5.20	4.50	5.79	6.01	7.56	6.44	8.04	7.09	8.75	8.20	9.93
RW5	0.02	2.60	2.65	3.34	3.41	3.72	3.79	4.85	4.95	5.16	5.25	5.61	5.71	6.36	6.48
RW6	0.015	3.03	3.03	3.81	3.81	4.19	4.19	5.33	5.33	5.64	5.64	6.09	6.09	6.83	6.83
RW6N1	0.009	1.35	1.35	1.74	1.74	1.93	1.93	2.50	2.50	2.66	2.66	2.89	2.89	3.26	3.26
RW7	0.026	3.24	2.85	4.20	3.80	4.70	4.29	6.27	5.82	6.70	6.24	7.33	6.89	8.39	7.99
RWJ1S1	0.026	4.73	4.73	5.99	5.99	6.62	6.62	8.49	8.49	8.99	8.99	9.73	9.73	10.96	10.96
RWJ1S2	0.012	2.33	2.33	2.92	2.92	3.22	3.22	4.09	4.09	4.33	4.33	4.67	4.67	5.25	5.25
RWJ1W1	0.089	15.28	16.97	19.42	21.31	21.52	23.47	27.90	29.89	29.61	31.58	32.16	34.12	36.41	38.32
RWJ1W2	0.068	11.38	13.06	14.52	16.40	16.13	18.06	21.04	22.99	22.35	24.29	24.32	26.24	27.59	29.47
RWJ1W3	0.04	6.87	7.62	8.75	9.57	9.70	10.54	12.59	13.42	13.35	14.18	14.50	15.32	16.40	17.20
RWJ2	0.128	15.77	17.04	20.37	22.00	22.74	24.52	30.01	32.17	31.99	34.22	34.99	37.31	40.00	42.48
RWJ3	0.11	13.78	14.27	17.70	18.45	19.71	20.58	25.90	27.06	27.58	28.80	30.12	31.43	34.36	35.82
RWJ4	0.102	13.02	13.65	16.71	17.60	18.59	19.60	24.38	25.69	25.95	27.33	28.33	29.78	32.29	33.90
RWJ5	0.07	9.98	9.72	12.79	12.53	14.21	13.95	18.55	18.28	19.71	19.45	21.45	21.21	24.34	24.16
RWJ6	0.051	7.45	7.17	9.52	9.23	10.57	10.28	13.79	13.50	14.65	14.37	15.95	15.68	18.10	17.88
RWJ6N1	0.009	1.35	1.35	1.74	1.74	1.93	1.93	2.50	2.50	2.66	2.66	2.89	2.89	3.26	3.26
RWJ7	0.026	3.24	2.85	4.20	3.80	4.70	4.29	6.27	5.82	6.70	6.24	7.33	6.89	8.39	7.99

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
RWR1-1S1	0.026	4.72	4.72	5.97	5.97	6.61	6.61	8.49	8.49	8.98	8.98	9.72	9.72	10.95	10.95
RWR1-1W1	0.089	15.21	16.88	19.35	21.20	21.45	23.34	27.81	29.73	29.51	31.42	32.06	33.95	36.28	38.14
RWR1-2	0.128	15.74	17.03	20.33	22.00	22.68	24.50	29.94	32.13	31.92	34.19	34.94	37.27	39.93	42.46
RWR1S1-1S2	0.012	2.33	2.33	2.92	2.92	3.22	3.22	4.09	4.09	4.33	4.33	4.67	4.67	5.25	5.25
RWR1W1-1W2	0.068	11.34	13.03	14.47	16.37	16.08	18.02	20.97	22.95	22.28	24.26	24.25	26.21	27.52	29.43
RWR1W2-1W3	0.04	6.86	7.61	8.73	9.56	9.68	10.53	12.57	13.40	13.33	14.17	14.48	15.30	16.38	17.18
RWR2-3	0.11	13.75	14.27	17.67	18.45	19.67	20.58	25.85	27.05	27.53	28.80	30.06	31.42	34.30	35.81
RWR3-4	0.102	13.00	13.61	16.68	17.55	18.56	19.56	24.34	25.64	25.91	27.28	28.28	29.74	32.24	33.84
RWR4-5	0.07	9.95	9.69	12.74	12.50	14.16	13.93	18.50	18.27	19.66	19.44	21.39	21.20	24.28	24.15
RWR5-6	0.051	7.43	7.16	9.49	9.23	10.54	10.28	13.75	13.48	14.61	14.35	15.90	15.66	18.05	17.86
RWR6-6N1	0.009	1.35	1.35	1.74	1.74	1.93	1.93	2.50	2.50	2.66	2.66	2.88	2.88	3.26	3.26
RWR6-7	0.026	3.23	2.85	4.20	3.78	4.70	4.27	6.27	5.79	6.69	6.22	7.33	6.87	8.39	7.97
SA1	0.014	2.55	2.55	3.20	3.20	3.52	3.52	4.49	4.49	4.74	4.74	5.13	5.13	5.76	5.76
SA2	0.031	4.32	5.00	5.63	6.41	6.30	7.12	8.39	9.24	8.95	9.80	9.78	10.65	11.18	12.04
SA3	0.011	0.80	1.50	1.04	1.93	1.17	2.15	1.56	2.81	1.67	2.99	1.83	3.25	2.12	3.68
SA4	0.015	1.29	2.47	1.73	3.17	1.95	3.51	2.65	4.55	2.85	4.82	3.15	5.24	3.67	5.91
SA4-R	0.015	0.75	0.98	0.90	2.26	0.97	2.86	1.86	4.44	2.18	4.78	2.66	5.20	3.42	5.88
SA5	0.02	2.65	3.80	3.39	4.77	3.77	5.25	4.93	6.68	5.25	7.06	5.74	7.63	6.57	8.57
SA5N1	0.033	5.15	5.15	6.52	6.52	7.22	7.22	9.36	9.36	9.94	9.94	10.80	10.80	12.23	12.23
SA5N1-R	0.033	2.73	2.73	3.09	3.09	3.23	3.23	7.21	7.21	8.16	8.16	9.56	9.56	11.63	11.63
SA6	0.014	2.17	2.17	2.77	2.77	3.09	3.09	4.05	4.05	4.31	4.31	4.71	4.71	5.36	5.36
SA7	0.021	2.86	2.88	3.71	3.75	4.16	4.19	5.54	5.58	5.91	5.96	6.46	6.52	7.39	7.45
SA7W	0.036	3.46	5.16	4.25	6.45	4.65	7.10	5.87	9.07	6.20	9.59	6.70	10.38	7.54	11.69
SA7W-R	0.036	2.03	2.18	2.24	4.16	2.98	5.43	5.07	8.55	5.57	9.26	6.30	10.26	7.44	11.66
SA8	0.017	3.24	2.95	4.06	3.76	4.47	4.17	5.70	5.41	6.02	5.74	6.51	6.23	7.31	7.05
SA9	0.043	7.74	7.74	9.86	9.86	10.93	10.93	14.18	14.18	15.04	15.04	16.33	16.33	18.47	18.47
SA9-R	0.043	4.07	4.07	4.59	4.59	4.83	4.83	11.29	11.29	12.71	12.71	14.87	14.87	18.03	18.03
SAJ2	0.241	23.46	25.91	28.82	31.86	31.53	34.86	42.73	53.09	48.33	59.92	56.59	69.88	69.48	85.35
SAJ3	0.21	19.43	21.17	23.48	25.72	25.55	28.74	36.62	46.51	41.52	52.63	48.58	61.27	59.63	74.75
SAJ4	0.199	18.67	19.71	22.51	23.84	24.46	26.73	35.22	44.13	39.96	50.00	46.91	58.22	57.70	71.40
SAJ5	0.184	18.16	18.96	21.90	22.94	23.81	24.96	34.27	40.96	38.74	46.36	45.44	53.91	55.82	66.05
SAJ5N1	0.033	2.73	2.73	3.09	3.09	3.23	3.23	7.21	7.21	8.16	8.16	9.56	9.56	11.63	11.63
SAJ6	0.132	13.25	13.06	16.03	15.88	17.45	17.34	26.05	30.15	29.11	33.71	33.18	38.99	39.59	47.52
SAJ7	0.118	11.19	11.00	13.37	13.23	14.48	14.37	22.93	27.28	25.46	30.52	29.10	35.25	34.42	42.46
SAJ8	0.06	6.78	6.48	7.99	7.68	8.59	8.29	16.01	15.73	17.95	17.67	20.88	20.61	25.17	24.91
SAJ9	0.043	4.07	4.07	4.59	4.59	4.83	4.83	11.29	11.29	12.71	12.71	14.87	14.87	18.03	18.03
SAR1-2	0.241	23.45	25.90	28.81	31.85	31.52	34.85	42.72	53.02	48.28	59.78	56.58	69.72	69.39	85.32
SAR2-3	0.21	19.40	21.15	23.44	25.71	25.50	28.70	36.57	46.37	41.48	52.26	48.55	60.87	59.30	74.46
SAR3-4	0.199	18.66	19.66	22.50	23.80	24.45	26.65	35.13	44.05	39.87	49.89	46.75	58.16	57.58	71.08
SAR4-5	0.184	18.14	18.95	21.89	22.93	23.79	24.95	34.20	40.84	38.73	46.33	45.30	53.90	55.76	65.95
SAR5-5N1	0.033	2.73	2.73	3.09	3.09	3.23	3.23	7.18	7.18	8.15	8.15	9.48	9.48	11.61	11.61
SAR5-6	0.132	13.25	13.05	16.02	15.87	17.43	17.32	26.03	29.93	28.86	33.66	33.11	38.97	39.41	47.37
SAR6-7	0.118	11.18	10.99	13.35	13.21	14.46	14.35	22.76	27.11	25.33	30.33	28.88	35.00	34.36	42.45
SAR7-8	0.06	6.78	6.48	7.98	7.68	8.59	8.29	15.91	15.63	17.92	17.65	20.72	20.45	24.96	24.70

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
SAR8-9	0.043	4.07	4.07	4.59	4.59	4.83	4.83	11.23	11.23	12.70	12.70	14.79	14.79	17.93	17.93
SL1	0.026	3.24	4.42	4.26	5.66	4.80	6.28	6.46	8.14	6.93	8.63	7.63	9.36	8.80	10.58
SL2	0.024	3.99	4.04	5.12	5.18	5.68	5.74	7.36	7.44	7.81	7.89	8.47	8.56	9.57	9.67
SL3	0.034	8.10	8.10	10.12	10.12	11.12	11.12	14.07	14.07	14.85	14.85	16.02	16.02	17.95	17.95
SL3E1	0.022	4.59	4.18	5.76	5.33	6.34	5.92	8.05	7.67	8.50	8.13	9.17	8.82	10.29	9.96
SL3S1	0.049	7.32	8.16	9.24	10.24	10.22	11.28	13.25	14.40	14.06	15.23	15.28	16.46	17.31	18.51
SL4	0.026	4.96	4.96	6.23	6.23	6.86	6.86	8.73	8.73	9.23	9.23	9.97	9.97	11.19	11.19
SL5	0.018	3.10	3.14	3.90	3.94	4.29	4.34	5.48	5.54	5.79	5.86	6.26	6.33	7.04	7.12
SL5N1	0.023	4.25	3.89	5.34	4.94	5.88	5.48	7.49	7.11	7.92	7.54	8.56	8.19	9.62	9.27
SL6	0.009	1.40	1.11	1.82	1.50	2.04	1.69	2.70	2.30	2.88	2.47	3.14	2.73	3.58	3.16
SL7	0.013	1.20	1.20	1.63	1.63	1.84	1.84	2.52	2.52	2.71	2.71	3.00	3.00	3.50	3.50
SL7N	0.005	0.90	0.90	1.13	1.13	1.24	1.24	1.59	1.59	1.68	1.68	1.81	1.81	2.04	2.04
SL8	0.015	1.77	1.77	2.31	2.31	2.59	2.59	3.44	3.44	3.67	3.67	4.02	4.02	4.62	4.62
SL8S1	0.008	1.49	1.63	1.90	2.05	2.10	2.26	2.73	2.87	2.89	3.03	3.14	3.27	3.55	3.68
SL8S1-R	0.008	0.75	0.82	0.91	0.99	0.99	1.07	2.12	2.54	2.43	2.81	2.91	3.30	3.49	3.78
SL9	0.03	3.79	5.06	4.98	6.48	5.60	7.19	7.54	9.32	8.08	9.88	8.89	10.72	10.26	12.12
SL9E1	0.011	0.73	1.66	0.96	2.13	1.09	2.37	1.47	3.07	1.57	3.26	1.73	3.54	2.01	4.01
SL9-R	0.03	2.18	2.55	2.53	4.15	2.69	5.59	6.00	8.99	6.92	9.69	8.16	10.68	10.10	12.07
SL9W	0.007	1.14	1.14	1.46	1.46	1.62	1.62	2.10	2.10	2.23	2.23	2.42	2.42	2.73	2.73
SL9W-R	0.007	0.54	0.54	0.68	0.68	0.74	0.74	1.53	1.53	1.80	1.80	2.14	2.14	2.72	2.72
SLA	0.009	1.25	1.79	1.61	2.25	1.79	2.48	2.35	3.15	2.51	3.33	2.74	3.60	3.14	4.04
SLB	0.012	0.81	2.13	1.14	2.72	1.31	3.02	1.83	3.91	1.97	4.15	2.19	4.50	2.56	5.08
SLJ2	0.313	45.07	48.19	57.05	61.11	63.05	67.51	81.04	89.17	85.81	96.42	92.96	107.01	111.71	123.23
SLJ3	0.289	41.12	44.26	51.98	56.11	57.43	61.98	73.75	82.24	78.08	88.86	85.21	98.89	103.06	113.76
SLJ3E1	0.022	4.59	4.18	5.76	5.33	6.34	5.92	8.05	7.67	8.50	8.13	9.17	8.82	10.29	9.96
SLJ3S1	0.049	7.32	8.16	9.24	10.24	10.22	11.28	13.25	14.40	14.06	15.23	15.28	16.46	17.31	18.51
SLJ4	0.186	22.55	25.14	28.67	31.96	31.73	35.31	40.85	49.90	44.54	54.27	51.80	60.66	62.74	70.40
SLJ5	0.16	17.78	20.29	22.69	25.87	25.16	28.60	32.92	41.92	37.14	45.73	43.37	51.20	52.50	59.76
SLJ5N1	0.023	4.25	3.89	5.34	4.94	5.88	5.48	7.49	7.11	7.92	7.54	8.56	8.19	9.62	9.27
SLJ6	0.119	10.59	13.39	13.65	17.07	15.19	19.11	22.28	29.86	25.44	32.92	30.00	37.01	36.58	43.73
SLJ7	0.11	9.41	12.43	12.05	15.71	13.37	18.09	20.42	27.91	23.30	30.81	27.46	34.55	33.38	40.86
SLJ7N	0.005	0.90	0.90	1.13	1.13	1.24	1.24	1.59	1.59	1.68	1.68	1.81	1.81	2.04	2.04
SLJ8	0.092	7.46	10.36	9.44	13.00	10.38	15.51	17.03	24.01	19.50	26.54	22.98	29.78	28.06	35.40
SLJ8S1	0.008	0.75	0.82	0.91	0.99	0.99	1.07	2.12	2.54	2.43	2.81	2.91	3.30	3.49	3.78
SLJ9	0.069	5.15	7.96	6.49	9.93	7.10	12.39	12.22	19.50	14.10	20.99	16.60	22.95	20.29	27.29
SLJ9E	0.011	0.73	1.66	0.96	2.13	1.09	2.37	1.47	3.07	1.57	3.26	1.73	3.54	2.01	4.01
SLJA	0.021	2.05	3.91	2.73	4.97	3.08	5.49	4.16	7.05	4.46	7.47	4.91	8.09	5.67	9.11
SLJB	0.012	0.81	2.13	1.14	2.72	1.31	3.02	1.83	3.91	1.97	4.15	2.19	4.50	2.56	5.08
SLR1-2	0.313	44.95	48.13	56.89	61.06	62.85	67.50	80.81	88.82	85.54	96.13	92.78	106.87	111.65	122.75
SLR2-3	0.289	41.11	44.20	51.97	56.00	57.41	61.83	73.73	82.00	78.07	88.81	85.00	98.54	102.61	113.66
SLR3-3E1	0.022	4.58	4.17	5.75	5.32	6.32	5.91	8.03	7.65	8.48	8.11	9.15	8.79	10.27	9.93
SLR3-3S1	0.049	7.31	8.15	9.22	10.24	10.20	11.28	13.23	14.40	14.04	15.22	15.26	16.46	17.28	18.51
SLR3-4	0.186	22.53	25.12	28.65	31.95	31.71	35.30	40.82	49.88	44.48	54.20	51.78	60.65	62.70	70.39
SLR4-5	0.16	17.77	20.28	22.69	25.85	25.16	28.59	32.90	41.90	37.13	45.72	43.35	51.18	52.47	59.75

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
SLR5-5N1	0.023	4.25	3.88	5.33	4.93	5.87	5.47	7.49	7.10	7.91	7.53	8.55	8.18	9.61	9.26
SLR5-6	0.119	10.58	13.38	13.65	17.02	15.18	19.06	22.18	29.81	25.41	32.85	29.88	36.91	36.45	43.64
SLR6-7	0.11	9.40	12.42	12.04	15.68	13.36	18.07	20.37	27.91	23.30	30.75	27.42	34.48	33.35	40.78
SLR7-7N	0.005	0.90	0.90	1.12	1.12	1.24	1.24	1.58	1.58	1.67	1.67	1.81	1.81	2.03	2.03
SLR7-8	0.092	7.46	10.36	9.43	12.98	10.38	15.51	17.00	23.99	19.50	26.50	22.97	29.75	27.93	35.34
SLR8-8S1	0.008	0.75	0.82	0.91	0.99	0.99	1.07	2.11	2.48	2.38	2.73	2.82	3.19	3.48	3.70
SLR8-9	0.069	5.15	7.96	6.48	9.93	7.10	12.34	12.21	19.35	14.09	20.83	16.59	22.94	20.08	27.25
SLR9-9E	0.011	0.73	1.66	0.96	2.13	1.09	2.36	1.47	3.07	1.57	3.26	1.73	3.54	2.01	4.00
SLR9-A	0.021	2.05	3.91	2.73	4.97	3.07	5.49	4.16	7.05	4.46	7.47	4.90	8.08	5.66	9.11
SLRA-B	0.012	0.81	2.13	1.14	2.72	1.31	3.02	1.82	3.91	1.97	4.15	2.19	4.50	2.56	5.08
SS1	0.009	2.59	2.59	3.22	3.22	3.53	3.53	4.45	4.45	4.70	4.70	5.06	5.06	5.67	5.67
SS2	0.008	2.39	2.39	2.97	2.97	3.25	3.25	4.10	4.10	4.33	4.33	4.66	4.66	5.22	5.22
SS3	0.022	3.72	4.21	4.84	5.37	5.42	5.95	7.16	7.67	7.62	8.12	8.31	8.80	9.45	9.92
SS4	0.009	1.69	1.69	2.12	2.12	2.33	2.33	2.97	2.97	3.14	3.14	3.39	3.39	3.81	3.81
SS5	0.009	1.72	1.89	2.19	2.37	2.43	2.61	3.15	3.31	3.34	3.50	3.63	3.78	4.10	4.24
SS6	0.019	3.86	3.86	4.85	4.85	5.34	5.34	6.79	6.79	7.17	7.17	7.75	7.75	8.70	8.70
SS6W1	0.012	2.05	2.05	2.62	2.62	2.91	2.91	3.77	3.77	3.99	3.99	4.33	4.33	4.90	4.90
SS6W1W	0.014	2.23	2.53	2.90	3.23	3.25	3.58	4.30	4.63	4.58	4.90	5.00	5.32	5.70	6.00
SS7	0.016	1.80	2.62	2.41	3.36	2.72	3.73	3.70	4.83	3.97	5.12	4.38	5.56	5.08	6.29
SSJ1	0.118	20.20	21.86	25.88	27.80	28.75	30.75	37.41	39.55	39.72	41.88	43.19	45.36	48.95	51.13
SSJ2	0.109	18.34	20.07	23.55	25.50	26.19	28.21	34.13	36.27	36.25	38.40	39.42	41.58	44.70	46.85
SSJ3	0.101	16.75	18.49	21.55	23.51	23.99	26.01	31.32	33.46	33.28	35.43	36.21	38.37	41.09	43.24
SSJ4	0.079	13.21	14.45	16.91	18.34	18.78	20.27	24.42	26.05	25.93	27.58	28.19	29.86	31.96	33.64
SSJ5	0.07	11.54	12.79	14.82	16.25	16.48	17.98	21.49	23.12	22.84	24.48	24.84	26.51	28.20	29.87
SSJ6	0.061	9.87	10.95	12.68	13.94	14.11	15.43	18.41	19.88	19.57	21.06	21.29	22.81	24.18	25.72
SSJ6W1	0.026	4.25	4.56	5.50	5.83	6.13	6.47	8.04	8.37	8.55	8.87	9.31	9.62	10.57	10.87
SSJ7	0.016	1.80	2.62	2.41	3.36	2.72	3.73	3.70	4.83	3.97	5.12	4.38	5.56	5.08	6.29
SSR1-2	0.109	18.33	20.06	23.54	25.49	26.18	28.20	34.12	36.26	36.24	38.39	39.41	41.57	44.69	46.85
SSR2-3	0.101	16.72	18.45	21.52	23.47	23.94	25.97	31.27	33.41	33.23	35.38	36.16	38.32	41.04	43.19
SSR3-4	0.079	13.18	14.41	16.87	18.30	18.74	20.24	24.38	26.01	25.89	27.54	28.14	29.82	31.91	33.59
SSR4-5	0.07	11.52	12.76	14.79	16.22	16.45	17.94	21.45	23.08	22.79	24.44	24.80	26.47	28.15	29.83
SSR5-6	0.061	9.85	10.93	12.66	13.92	14.08	15.41	18.38	19.85	19.54	21.03	21.26	22.78	24.15	25.69
SSR6-6W1	0.026	4.25	4.55	5.50	5.83	6.13	6.47	8.04	8.36	8.55	8.87	9.30	9.62	10.56	10.86
SSR6-7	0.016	1.80	2.61	2.40	3.35	2.72	3.72	3.69	4.83	3.96	5.12	4.37	5.56	5.08	6.29
ST1	0.044	2.45	2.45	3.02	3.02	3.34	3.34	4.33	4.33	4.60	4.60	5.01	5.01	5.71	5.71
ST2	0.066	4.93	4.93	6.53	6.53	7.34	7.34	9.93	9.93	10.66	10.66	11.75	11.75	13.65	13.65
STJ2	0.066	4.93	4.93	6.53	6.53	7.34	7.34	9.93	9.93	10.66	10.66	11.75	11.75	13.65	13.65
STR1-2	0.066	4.93	4.93	6.53	6.53	7.34	7.34	9.92	9.92	10.64	10.64	11.73	11.73	13.64	13.64
TA1	0.018	5.36	5.36	6.66	6.66	7.30	7.30	9.20	9.20	9.70	9.70	10.46	10.46	11.70	11.70
TA2	0.017	4.23	4.23	5.27	5.27	5.79	5.79	7.32	7.32	7.72	7.72	8.33	8.33	9.33	9.33
TA3	0.008	1.07	1.15	1.34	1.44	1.48	1.59	1.92	2.03	2.04	2.15	2.21	2.32	2.51	2.62
TA3E	0.014	2.58	2.83	3.28	3.55	3.64	3.91	4.72	4.97	5.01	5.25	5.44	5.67	6.15	6.37
TA3E1	0.033	4.25	5.40	5.60	6.92	6.30	7.69	8.48	9.97	9.08	10.57	9.99	11.48	11.52	12.97
TA3W	0.009	1.49	1.78	1.92	2.24	2.14	2.46	2.81	3.14	2.99	3.31	3.26	3.58	3.72	4.02

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
TA4	0.026	5.06	5.06	6.36	6.36	7.00	7.00	8.91	8.91	9.42	9.42	10.17	10.17	11.42	11.42
TA4E	0.012	2.29	2.29	2.88	2.88	3.17	3.17	4.04	4.04	4.27	4.27	4.61	4.61	5.18	5.18
TA4E1	0.013	1.93	2.23	2.52	2.85	2.82	3.16	3.74	4.10	3.99	4.35	4.36	4.72	4.98	5.33
TA4W	0.013	2.15	2.40	2.72	3.02	3.02	3.32	3.92	4.24	4.16	4.48	4.51	4.84	5.11	5.43
TA5	0.023	3.19	3.19	4.15	4.15	4.64	4.64	6.18	6.18	6.59	6.59	7.21	7.21	8.24	8.24
TA5E1	0.02	1.66	2.65	2.15	3.41	2.41	3.79	3.22	4.95	3.45	5.25	3.79	5.71	4.38	6.48
TA5E2	0.022	3.01	3.84	3.97	4.92	4.47	5.46	6.03	7.06	6.46	7.49	7.10	8.12	8.18	9.17
TA5-R	0.023	1.75	1.75	2.06	2.06	2.18	2.18	4.71	4.71	5.43	5.43	6.43	6.43	7.90	7.90
TA6	0.05	5.14	8.34	6.81	10.69	7.68	11.87	10.40	15.37	11.17	16.30	12.32	17.69	14.30	19.99
TA6W1	0.014	2.54	2.24	3.25	2.92	3.61	3.27	4.66	4.33	4.94	4.61	5.36	5.04	6.05	5.74
TA6W1N	0.018	3.51	3.51	4.41	4.41	4.85	4.85	6.17	6.17	6.52	6.52	7.05	7.05	7.91	7.91
TA6W1N-R	0.018	1.96	1.96	2.22	2.22	2.33	2.33	4.68	4.68	5.31	5.31	6.23	6.23	7.62	7.62
TA6W1-R	0.014	1.28	1.13	1.58	1.41	1.68	1.54	3.67	2.78	4.14	3.35	4.87	4.11	5.90	5.25
TA7	0.017	2.11	2.11	2.71	2.71	3.02	3.02	3.95	3.95	4.19	4.19	4.56	4.56	5.18	5.18
TA7W1	0.02	3.01	3.01	3.89	3.89	4.34	4.34	5.76	5.76	6.14	6.14	6.73	6.73	7.71	7.71
TA7W1-R	0.02	1.70	1.70	1.94	1.94	2.03	2.03	4.24	4.24	4.93	4.93	5.90	5.90	7.40	7.40
TA7W2	0.027	4.32	4.32	5.49	5.49	6.08	6.08	7.90	7.90	8.38	8.38	9.10	9.10	10.30	10.30
TA7W2-R	0.027	2.47	2.47	2.79	2.79	2.95	2.95	6.35	6.35	7.11	7.11	8.19	8.19	9.94	9.94
TA8	0.046	4.13	5.52	5.32	7.10	5.95	7.90	7.90	10.33	8.46	10.98	9.31	11.96	10.74	13.58
TA8E1	0.035	4.35	6.63	5.52	8.32	6.12	9.16	7.98	11.66	8.49	12.33	9.26	13.31	10.57	14.95
TA8E1-R	0.035	2.66	3.00	3.01	4.78	3.14	6.53	6.14	10.70	7.01	11.71	8.20	13.09	10.05	14.84
TA8E2	0.044	2.85	7.27	3.92	9.33	4.46	10.36	6.14	13.43	6.61	14.25	7.32	15.46	8.53	17.48
TA8W1	0.024	3.23	2.86	4.15	3.70	4.62	4.14	6.03	5.53	6.40	5.90	6.96	6.46	7.89	7.40
TA8W2	0.038	7.36	7.36	9.23	9.23	10.17	10.17	12.94	12.94	13.68	13.68	14.78	14.78	16.59	16.59
TA8W3	0.022	5.98	5.98	7.52	7.52	8.28	8.28	10.56	10.56	11.16	11.16	12.06	12.06	13.55	13.55
TA8W3-R	0.022	2.78	2.78	3.13	3.13	3.29	3.29	8.87	8.87	9.85	9.85	11.55	11.55	13.55	13.55
TA9	0.026	3.83	3.57	4.82	4.53	5.33	5.02	6.91	6.53	7.34	6.94	7.97	7.57	9.03	8.63
TA9E1	0.037	2.06	6.74	2.94	8.61	3.46	9.55	5.02	12.33	5.46	13.07	6.12	14.17	7.24	15.99
TA9E2	0.013	2.47	2.47	3.11	3.11	3.42	3.42	4.36	4.36	4.60	4.60	4.97	4.97	5.59	5.59
TA9E2-R	0.013	1.32	1.32	1.56	1.56	1.63	1.63	3.33	3.33	3.76	3.76	4.40	4.40	5.34	5.34
TA9E3	0.025	3.07	4.05	4.03	5.19	4.53	5.76	6.10	7.48	6.54	7.93	7.20	8.61	8.31	9.73
TA9E3-R	0.025	1.70	2.02	2.01	3.10	2.13	4.35	4.71	7.14	5.46	7.77	6.50	8.57	8.06	9.71
TA9-R	0.026	1.81	1.77	2.03	1.99	2.11	2.07	5.04	4.15	5.82	4.95	6.86	6.09	8.45	7.74
TAA	0.032	4.46	5.12	5.73	6.57	6.39	7.31	8.42	9.60	8.97	10.22	9.81	11.16	11.24	12.72
TAB	0.024	1.65	3.28	2.11	4.22	2.34	4.70	3.09	6.13	3.29	6.51	3.61	7.09	4.15	8.03
TAC	0.019	2.05	2.90	2.57	3.63	2.83	4.00	3.65	5.11	3.87	5.40	4.20	5.85	4.76	6.58
TAC-R	0.019	1.33	1.44	1.47	2.00	1.54	2.88	2.84	4.75	3.20	5.17	3.76	5.76	4.59	6.56
TAD	0.021	2.85	2.67	3.62	3.41	4.01	3.79	5.22	4.96	5.55	5.28	6.06	5.77	6.90	6.59
TAD-R	0.021	1.71	1.66	1.91	1.87	2.01	1.96	4.15	3.61	4.73	4.20	5.51	5.03	6.70	6.24
TAE	0.023	2.46	2.23	3.17	2.89	3.54	3.24	4.72	4.33	5.04	4.63	5.52	5.10	6.33	5.89
TAF	0.035	4.54	5.49	5.90	7.05	6.61	7.83	8.81	10.17	9.40	10.80	10.29	11.73	11.77	13.27
TAJ1	1.094	109.64	133.04	138.21	167.11	152.56	183.97	199.61	246.99	221.68	268.81	254.65	310.44	310.33	376.15
TAJ2	1.076	107.38	130.71	135.27	164.04	149.29	180.55	195.73	242.85	218.28	265.39	250.60	306.41	305.56	371.16
TAJ3	1.059	104.94	128.19	132.14	160.77	145.82	176.90	192.47	238.49	214.65	261.74	246.31	302.15	300.55	365.86

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
TAJ3E1	0.033	4.25	5.40	5.60	6.92	6.30	7.69	8.48	9.97	9.08	10.57	9.99	11.48	11.52	12.97
TAJ4	0.995	97.02	118.16	121.63	147.85	133.97	162.53	179.52	220.56	200.10	245.06	229.41	283.20	280.93	343.06
TAJ4E1	0.013	1.93	2.23	2.52	2.85	2.82	3.16	3.74	4.10	3.99	4.35	4.36	4.72	4.98	5.33
TAJ5E1	0.042	4.44	6.37	5.80	8.18	6.50	9.09	8.70	11.80	9.31	12.52	10.23	13.60	11.79	15.39
TAJ5E2	0.022	3.01	3.84	3.97	4.92	4.47	5.46	6.03	7.06	6.46	7.49	7.10	8.12	8.18	9.17
TAJ5-SAJ1	0.93	87.08	107.30	108.81	134.01	119.75	147.20	164.34	202.99	183.17	227.64	210.15	263.18	258.87	318.76
TAJ6	0.61	56.19	71.50	70.28	89.52	77.36	98.36	106.67	137.57	117.94	150.92	135.41	173.36	167.54	207.15
TAJ6W1	0.032	3.25	3.09	3.79	3.62	4.01	3.87	8.13	7.36	9.30	8.59	10.96	10.23	13.40	12.86
TAJ7	0.528	48.71	61.32	60.70	76.51	66.74	84.02	90.43	119.87	99.64	129.36	116.75	147.90	143.73	176.14
TAJ7W1	0.047	4.16	4.16	4.73	4.73	4.99	4.99	10.40	10.40	11.80	11.80	13.79	13.79	17.04	17.04
TAJ7W2	0.027	2.47	2.47	2.79	2.79	2.95	2.95	6.35	6.35	7.11	7.11	8.19	8.19	9.94	9.94
TAJ8	0.465	42.85	55.68	53.73	69.81	59.27	76.78	78.49	111.01	85.61	119.90	100.32	131.57	123.32	154.43
TAJ8E1	0.079	5.27	9.77	6.50	12.10	7.13	14.32	11.29	23.51	12.75	25.67	14.92	28.51	18.31	32.28
TAJ8E2	0.044	2.85	7.27	3.92	9.33	4.46	10.36	6.14	13.43	6.61	14.25	7.32	15.46	8.53	17.48
TAJ8W1	0.085	13.09	12.75	16.22	15.79	17.74	17.27	26.71	26.22	28.97	28.47	31.59	31.09	35.76	35.27
TAJ8W2	0.061	9.99	9.99	12.25	12.25	13.31	13.31	21.42	21.42	23.35	23.35	25.55	25.55	29.05	29.05
TAJ8W3	0.022	2.78	2.78	3.13	3.13	3.29	3.29	8.87	8.87	9.85	9.85	11.55	11.55	13.55	13.55
TAJ9	0.255	21.08	28.03	26.51	35.26	29.33	38.83	40.52	53.62	46.23	57.91	54.47	65.99	66.68	80.70
TAJ9E1	0.075	5.03	9.08	6.23	11.46	6.81	12.63	12.34	19.48	13.99	21.29	16.45	24.16	20.43	29.73
TAJ9E2	0.038	3.01	3.34	3.57	4.64	3.75	5.88	8.02	9.31	9.15	10.50	10.79	12.24	13.34	14.93
TAJ9E3	0.025	1.70	2.02	2.01	3.10	2.13	4.35	4.71	7.14	5.46	7.77	6.50	8.57	8.06	9.71
TAJA	0.155	14.79	17.82	18.75	22.70	20.80	25.16	27.05	32.53	28.79	35.69	33.15	40.36	39.46	48.74
TAJB	0.122	10.79	13.27	13.63	16.77	15.06	18.50	19.92	25.36	22.19	27.60	25.21	31.60	30.77	38.35
TAJC	0.098	9.23	10.02	11.65	12.59	12.88	13.84	16.91	19.71	18.90	21.60	21.74	25.30	26.71	30.61
TAJD	0.079	8.24	8.89	10.50	11.27	11.67	12.47	15.42	15.99	17.41	16.94	20.24	19.81	24.29	24.17
TAJE	0.059	6.87	7.59	8.92	9.74	9.97	10.84	13.31	14.16	14.21	15.07	15.56	16.44	17.82	18.72
TAJF	0.035	4.54	5.49	5.90	7.05	6.61	7.83	8.81	10.17	9.40	10.80	10.29	11.73	11.77	13.27
TAR1-2	1.076	107.30	130.62	135.20	163.87	149.22	180.39	195.69	242.68	218.17	265.30	250.56	306.08	305.40	370.57
TAR2-3	1.059	104.86	128.08	132.06	160.59	145.74	176.73	192.41	238.31	214.53	261.64	246.28	301.81	300.37	365.30
TAR3-3E1	0.033	4.24	5.38	5.58	6.90	6.28	7.66	8.45	9.94	9.05	10.55	9.96	11.45	11.49	12.94
TAR3-4	0.995	96.90	118.01	121.43	147.50	133.77	162.21	179.24	220.18	199.85	244.82	229.39	282.49	280.38	342.14
TAR4-4E1	0.013	1.93	2.22	2.51	2.85	2.81	3.16	3.74	4.10	3.99	4.34	4.36	4.71	4.97	5.33
TAR4-5	0.93	87.07	107.21	108.74	133.75	119.62	146.96	164.01	202.61	182.98	227.45	210.12	262.70	258.35	318.27
TAR5-5E1	0.042	4.42	6.36	5.79	8.16	6.49	9.06	8.69	11.77	9.29	12.49	10.21	13.57	11.77	15.35
TAR5-6	0.61	56.19	71.49	70.23	89.42	77.30	98.21	106.60	137.32	117.89	150.89	135.33	173.11	167.41	206.57
TAR5E1-5E2	0.022	3.01	3.83	3.97	4.90	4.47	5.43	6.01	7.04	6.44	7.47	7.08	8.10	8.16	9.16
TAR6-6W1	0.032	3.25	3.09	3.79	3.62	4.01	3.87	8.09	7.27	9.17	8.49	10.78	10.18	13.32	12.73
TAR6-7	0.528	48.70	61.30	60.67	76.50	66.68	83.94	90.30	119.63	99.59	129.25	116.69	147.73	143.55	175.62
TAR7-7W1	0.047	4.16	4.16	4.73	4.73	4.99	4.99	10.32	10.32	11.74	11.74	13.75	13.75	16.89	16.89
TAR7-8	0.465	42.80	55.54	53.69	69.69	59.23	76.68	78.43	110.96	85.38	119.55	100.32	131.14	123.20	154.18
TAR7W1-7W2	0.027	2.47	2.47	2.79	2.79	2.95	2.95	6.30	6.30	7.08	7.08	8.18	8.18	9.87	9.87
TAR8-8E1	0.079	5.27	9.75	6.50	12.08	7.13	14.24	11.26	23.28	12.74	25.47	14.89	28.34	18.32	32.26
TAR8-8W1	0.085	13.09	12.73	16.22	15.77	17.73	17.24	26.81	26.32	28.83	28.35	31.64	31.14	35.69	35.16
TAR8-9	0.255	21.07	27.99	26.51	35.23	29.32	38.81	40.38	53.54	46.14	57.69	54.35	65.79	66.49	80.26

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

		2-YEAR		5-YEAR		10-YEAR		25-YEAR		50-YEAR		100-YEAR		500-YEAR	
		Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
ID	Drainage Area (mi^2)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)	Qpeak (cfs)
TAR8E1-8E2	0.044	2.85	7.25	3.92	9.30	4.46	10.33	6.14	13.39	6.61	14.21	7.31	15.42	8.52	17.43
TAR8W1-8W2	0.061	9.98	9.98	12.20	12.20	13.26	13.26	21.11	21.11	23.01	23.01	25.49	25.49	28.83	28.83
TAR8W2-8W3	0.022	2.77	2.77	3.13	3.13	3.29	3.29	8.47	8.47	9.77	9.77	11.27	11.27	13.20	13.20
TAR9-9E1	0.075	5.03	9.04	6.23	11.43	6.80	12.60	12.23	19.27	13.90	21.02	16.34	24.02	20.17	29.63
TAR9-A	0.155	14.77	17.81	18.73	22.68	20.78	25.15	27.00	32.48	28.72	35.63	33.01	40.14	39.39	48.50
TAR9E1-9E2	0.038	3.01	3.34	3.57	4.63	3.75	5.87	8.00	9.29	9.10	10.50	10.72	12.24	13.29	14.88
TAR9E2-9E3	0.025	1.70	2.02	2.01	3.09	2.13	4.29	4.70	7.03	5.39	7.67	6.40	8.51	8.00	9.70
TARA-B	0.122	10.78	13.27	13.62	16.77	15.04	18.49	19.82	25.23	22.05	27.56	25.06	31.57	30.65	38.14
TARB-C	0.098	9.22	10.01	11.64	12.57	12.86	13.82	16.88	19.68	18.89	21.59	21.65	25.16	26.62	30.60
TARC-D	0.079	8.23	8.89	10.50	11.27	11.67	12.46	15.40	15.99	17.38	16.94	20.23	19.79	24.29	24.17
TARD-E	0.059	6.87	7.58	8.91	9.73	9.96	10.82	13.29	14.15	14.19	15.05	15.55	16.42	17.81	18.70
TARE-F	0.035	4.54	5.48	5.90	7.04	6.60	7.82	8.80	10.16	9.40	10.78	10.29	11.72	11.77	13.26
TR1	0.048	5.73	5.81	7.08	7.19	7.77	7.90	9.87	10.04	10.44	10.62	11.29	11.49	12.71	12.94
TR2	0.017	1.26	2.04	1.63	2.63	1.82	2.93	2.41	3.83	2.58	4.07	2.84	4.43	3.28	5.03
TR2S1	0.033	4.71	4.75	6.05	6.11	6.73	6.79	8.77	8.84	9.31	9.39	10.12	10.20	11.46	11.55
TR3	0.032	4.31	5.63	5.52	7.08	6.14	7.79	8.05	9.94	8.58	10.51	9.37	11.36	10.72	12.76
TR4	0.005	1.00	1.00	1.25	1.25	1.38	1.38	1.75	1.75	1.85	1.85	2.00	2.00	2.25	2.25
TR5	0.039	5.63	6.83	7.17	8.58	7.96	9.45	10.40	12.05	11.06	12.74	12.08	13.77	13.77	15.48
TR6	0.025	1.40	1.40	1.82	1.70	2.16	1.98	3.23	3.04	3.52	3.33	3.96	3.76	4.71	4.49
TR7	0.059	5.57	6.22	6.94	7.84	7.63	8.66	9.73	11.19	10.30	11.88	11.16	12.93	12.62	14.69
TR8	0.055	6.94	6.50	8.98	8.49	10.02	9.51	13.21	12.64	14.09	13.49	15.41	14.78	17.67	16.97
TR9	0.03	4.22	4.22	5.49	5.49	6.14	6.14	8.16	8.16	8.71	8.71	9.52	9.52	10.87	10.87
TR9N	0.016	2.58	2.58	3.31	3.31	3.68	3.68	4.78	4.78	5.07	5.07	5.50	5.50	6.22	6.22
TRA	0.039	5.49	6.78	6.91	8.51	7.64	9.38	9.89	11.96	10.50	12.64	11.41	13.67	12.92	15.36
TRB	0.014	1.91	2.20	2.48	2.83	2.78	3.14	3.70	4.08	3.95	4.33	4.32	4.70	4.94	5.31
TRBS	0.046	5.06	5.90	6.47	7.52	7.19	8.35	9.41	10.90	10.02	11.60	10.93	12.66	12.47	14.46
TRC	0.022	4.05	4.05	5.08	5.08	5.60	5.60	7.13	7.13	7.53	7.53	8.14	8.14	9.14	9.14
TRJ1	0.886	119.71	126.48	152.67	161.09	169.44	178.78	220.21	232.41	233.84	246.91	254.52	268.73	288.88	304.79
TRJ2	0.838	114.88	121.48	146.71	155.06	162.88	172.15	211.92	223.97	225.08	237.87	244.83	258.74	277.83	293.63
TRJ2S1	0.033	4.71	4.75	6.05	6.11	6.73	6.79	8.77	8.84	9.31	9.39	10.12	10.20	11.46	11.55
TRJ3-RBJ1	0.789	109.18	114.89	139.41	146.59	154.77	162.72	201.36	211.65	213.86	224.78	232.62	244.49	263.95	277.45
TRJ4-GSJ1	0.577	80.44	82.56	102.09	104.92	113.13	116.39	146.61	151.20	155.58	160.54	169.02	174.58	191.44	198.08
TRJ5	0.432	56.31	58.83	71.49	74.71	79.34	82.91	103.23	107.97	109.64	114.73	119.28	124.88	135.42	141.94
TRJ6	0.393	50.93	52.24	64.57	66.44	71.60	73.80	93.04	96.36	98.80	102.46	107.45	111.62	121.92	127.02
TRJ7	0.368	49.67	50.94	62.92	64.88	69.64	71.96	90.03	93.53	95.49	99.36	103.69	108.11	117.39	122.81
TRJ8	0.309	44.26	45.00	56.42	57.42	62.60	63.74	81.39	83.03	86.44	88.24	94.02	96.08	106.70	109.24
TRJ9	0.166	22.99	25.57	29.36	32.49	32.59	35.99	42.45	46.58	45.09	49.42	49.04	53.69	55.66	60.80
TRJA	0.12	16.39	18.83	20.78	23.75	23.00	26.23	29.79	33.72	31.61	35.74	34.35	38.76	38.94	43.82
TRJB	0.082	10.94	12.11	13.90	15.34	15.40	16.97	19.96	21.92	21.19	23.25	23.03	25.26	26.12	28.64
TRJC	0.022	4.05	4.05	5.08	5.08	5.60	5.60	7.13	7.13	7.53	7.53	8.14	8.14	9.14	9.14
TRR1-2	0.838	114.76	121.36	146.56	154.77	162.74	171.83	211.69	223.56	224.82	237.54	244.75	258.59	277.86	293.36
TRR2-2S1	0.033	4.69	4.74	6.04	6.10	6.72	6.78	8.75	8.83	9.29	9.37	10.10	10.19	11.44	11.54
TRR2-3	0.789	109.04	114.78	139.23	146.45	154.57	162.57	201.12	211.47	213.61	224.59	232.36	244.30	263.68	277.25
TRR3-4	0.577	80.21	82.25	101.83	104.55	112.86	115.98	146.30	150.70	155.25	160.02	168.68	174.01	191.08	197.43

Appendix B

HEC-HMS SUMMARY OF PEAK FLOWS WITH DETENTION FACILITIES

ID	Drainage Area (mi²)	2-YEAR Existing Qpeak (cfs)	2-YEAR Future Qpeak (cfs)	5-YEAR Existing Qpeak (cfs)	5-YEAR Future Qpeak (cfs)	10-YEAR Existing Qpeak (cfs)	10-YEAR Future Qpeak (cfs)	25-YEAR Existing Qpeak (cfs)	25-YEAR Future Qpeak (cfs)	50-YEAR Existing Qpeak (cfs)	50-YEAR Future Qpeak (cfs)	100-YEAR Existing Qpeak (cfs)	100-YEAR Future Qpeak (cfs)	500-YEAR Existing Qpeak (cfs)	500-YEAR Future Qpeak (cfs)
TRR4-5	0.432	56.28	58.67	71.48	74.54	79.32	82.74	103.17	107.83	109.58	114.60	119.21	124.77	135.34	141.82
TRR5-6	0.393	50.84	52.08	64.51	66.23	71.56	73.58	93.02	96.16	98.78	102.25	107.42	111.42	121.88	126.81
TRR6-7	0.368	49.56	50.87	62.75	64.76	69.44	71.82	89.85	93.32	95.33	99.13	103.55	107.86	117.28	122.53
TRR7-8	0.309	44.24	44.87	56.39	57.32	62.55	63.65	81.31	82.99	86.35	88.21	93.92	96.07	106.58	109.23
TRR8-9	0.166	22.99	25.45	29.33	32.38	32.55	35.88	42.38	46.46	45.01	49.30	48.96	53.55	55.57	60.65
TRR9-A	0.12	16.38	18.79	20.75	23.72	22.97	26.21	29.75	33.72	31.58	35.73	34.33	38.76	38.94	43.82
TRRA-B	0.082	10.91	12.06	13.89	15.30	15.39	16.93	19.93	21.89	21.15	23.23	22.98	25.25	26.06	28.63
TRRB-C	0.022	4.03	4.03	5.07	5.07	5.58	5.58	7.11	7.11	7.51	7.51	8.12	8.12	9.12	9.12

Appendix C
CULVERT AND PIPE INVENTORY WITH HYDRAULIC DEFICIENCIES

						Existing Structure								25-Year Design Flow (cfs)		Is it Deficient?		100-Year Design Flow (cfs)		Is it Deficient?	
Count	Watershed	PWR ID	HEC-HMS Subbasin	Drainage Area (mi^2)	Location / Description	Diam (ft)	Length (ft)	Inlet Type	Material	Shape	Slope (ft/ft)	Capacity (cfs)	Structure Type	Existing	Future	Now	Future	Existing	Future	Now	Future
1	ARBOR	495	ARJ5N1	0.156	PIPE FROM SCENIC DR TO HILLSIDE DR.	1.50	400	HW45	CONC	CIRC	0.170	24.5	P	18.6	19.4	NO	NO	21.4	22.3	NO	NO
2	ARBOR	496	ARJ9	0.033	FROM BRAEMAR CT TO SKYE PARKWAY	4.00	390	HW45	CMP	CIRC	0.164	4.0	P	11.2	10.7	YES	YES	12.8	12.3	YES	YES
3	ARBOR	497	ARR5-6	0.087	ENTRANCE TO PIEP SYSTEM UNDER UPPER MIDHILL	3.00	92	HW90	CONC	CIRC	0.158	103.9	C	24.2	26.4	NO	NO	27.7	30.4	NO	NO
4	ARBOR	657	ARJ3	0.356	CULVERT UNDER PACIFIC HIGHWAY NR ARBOR DR.	2.00	72	HW90	CONC	CIRC	0.083	70.8	C	66.2	72.8	NO	YES	76.6	84.0	YES	YES
5	ARBOR	659	ARR5-5N1	0.156	ENTRANCE TO PIPE SYSTEM UNDER COLLEGE HILLPL.	1.50	275	HW90	CONC	CIRC	0.113	55.1	C	18.6	19.4	NO	NO	21.4	22.3	NO	NO
6	ARBOR	660	ARR5-6	0.087	PIPE UNDER UPPER MIDHILL NR COLLEGE HILL PL.	2.00	33	HW45	CONC	CIRC	0.606	109.8	P	24.2	26.4	NO	NO	27.7	30.4	NO	NO
7	ARBOR	661	ARJ6	0.087	UNDER HILLSIDE CT.	4.00	150	PROJ	CONC	CIRC	0.173	161.6	C	24.2	26.4	NO	NO	27.7	30.4	NO	NO
8	ARBOR	662	ARJ5N2	0.062	ENTRANCE TO PIPE SYSTEM UNDER SKYE PARKWAY	3.00	420	HW90	CONC	CIRC	0.217	34.5	P	9.1	9.4	NO	NO	10.6	11.0	NO	NO
9	ARBOR	663	AR5N1W1	0.078	ENTRANCE TO PIPE SYSTEM AT SCENIC DR.	2.25	170	HW90	CONC	CIRC	0.382	19.7	P	7.4	7.4	NO	NO	8.5	8.5	NO	NO
10	ARBOR	664	ARJ8	0.049	UPSTREAM OF BRAEMAR CT.	4.00	120	HW45	CONC	CIRC	0.017	12.5	P	16.7	16.2	YES	YES	19.1	18.6	YES	YES
11	BARLOW	481	BAJ8	0.048	UNDER ROSEPARK DR. AT LUPIN CT.	3.00	60	PROJ	CMP	CIRC	0.117	39.9	C	7.3	10.2	NO	NO	8.3	11.6	NO	NO
12	BARLOW	597	BAJ6	0.127	UNDER SUMMIT ST AT HORTON RD.	3.00	140	PROJ	CMP	CIRC	0.050	10.9	C	26.2	29.8	YES	YES	30.0	34.4	YES	YES
13	BARLOW	598	BAJ5	0.142	UNDER RANDALL ST.	2.00	265	HW45	CONC	CIRC	0.159	70.8	P	28.5	33.4	NO	NO	32.8	38.7	NO	NO
14	BARLOW	599	BAJ5	0.142	PIPE ENTRANCE AT BUCK ST.	2.50	164	HW90	CMP	CIRC	0.048	46.8	C	28.5	33.4	NO	NO	32.8	38.7	NO	NO
15	BARLOW	600	BAJ3	0.184	PIPE UNDER LOWRY DR.	2.00	70	HW90	CONC	CIRC	0.214	34.5	C	39.2	46.0	YES	YES	45.2	53.1	YES	YES
16	BARLOW	601	BAJ4	0.159	UNDER WILLAMETTE DR. NR RANDALL ST.	2.25	87	PROJ	CMP	CIRC	0.082	39.9	C	32.2	38.9	NO	NO	37.2	45.0	NO	YES
17	BARLOW	602	BAJ4	0.159	UNDER WILLAMETTE DR. NR RANDALL ST.	2.00	110	PROJ	CMP	CIRC	0.167	22.8	C	32.2	38.9	YES	YES	37.2	45.0	YES	YES
18	BARLOW	603	BAR2-3	0.184	UNDER WILLAMETTE VIEW CT.	2.00	150	PROJ	CMP	CIRC	0.140	14.8	C	39.2	46.0	YES	YES	45.2	53.0	YES	YES
19	BARLOW	604	BAJ2	0.241	CULVERT UNDER FAILING STREET	2.00	317	PROJ	CMP	CIRC	0.098	9.1	C	55.6	62.9	YES	YES	64.3	72.6	YES	YES
20	BERNERT	443	BEJ5S1	0.021	UNDER 10TH STREET	1.00	600	HW45	CONC	CIRC	0.044	12.5	P	8.4	8.4	NO	NO	9.6	9.6	NO	NO
21	BERNERT	444	BER5W1-5W1S1	0.038	ALONG 13TH AVENUE	3.00	120	HW45	CONC	CIRC	0.029	4.5	P	12.3	12.3	YES	YES	14.0	14.0	YES	YES
22	BERNERT	445	BEJ5W1S1	0.038	FROM 16TH AVENUE TO 13TH AVENUE	1.25	1000	HW45	CONC	CIRC	0.050	4.5	P	12.3	12.3	YES	YES	14.1	14.1	YES	YES
23	BERNERT	446	BEJ5W1N1	0.059	UNDER I-205 AT 13TH AVENUE	2.50	526	HW45	CONC	CIRC	0.009	36.9	P	22.9	23.2	NO	NO	29.2	29.3	NO	NO
24	BERNERT	447	BEJ5W2	0.018	UNDER I-205 AT VIRGINIA LN.	3.50	288	HW45	CONC	CIRC	0.010	5.2	P	8.9	8.9	YES	YES	10.1	10.1	YES	YES
25	BERNERT	448	BEJ4N1	0.011	UNDER I-205	2.50	538	HW90	CMP	CIRC	0.210	8.1	C	2.1	2.1	NO	NO	2.8	2.8	NO	NO
26	BERNERT	449	BEJ4N1	0.011	ABOVE I-205	3.00	115	HW90	CONC	CIRC	0.280	7.9	C	2.1	2.1	NO	NO	2.8	2.8	NO	NO
27	BERNERT	450	BEJ9	0.019	ALONG TANNLER NR FALCON DR	1.50	214	HW90	CONC	CIRC	0.114	12.5	P	6.4	6.4	NO	NO	7.3	7.3	NO	NO
28	BERNERT	451	BEJ9	0.019	ALONG TANNLER NR FALCON DR	2.00	214	HW90	CONC	CIRC	0.079	9.1	P	6.4	6.4	NO	NO	7.3	7.3	NO	NO
29	BERNERT	452	BER3N1-3N2	0.049	DOWN TO WILLAMETTE FALLS DR.	3.00	484	PROJ	CONC	CIRC	0.178	28.6	C	5.7	8.7	NO	NO	6.7	10.1	NO	NO
30	BERNERT	453	BEJ3N2	0.049	UNDER SALAMO NR HALL CT.	1.50	150	HW45	CONC	CIRC	0.020	6.6	P	5.7	8.7	NO	YES	6.7	10.1	YES	YES
31	BERNERT	454	BE2W1	0.111	UNDER 9TH ST. NR VOLPP ST.	2.00	80	PROJ	CONC	CIRC	0.004	7.0	C	23.3	34.5	YES	YES	27.6	39.7	YES	YES
32	BERNERT	523	BER6-7	0.081	ALONG TANNER RD TO BLANKENSHIP RD	2.00	900	HW45	CONC	CIRC	0.128	70.8	P	15.1	23.6	NO	NO	20.6	29.3	NO	NO
33	BERNERT	524	BEJ7	0.081	ALONG TANNER D DOWNSTREAM OF GREENE ST	1.50	335	HW45	CMP	CIRC	0.119	26.1	P	15.2	23.7	NO	NO	20.6	29.6	NO	YES
34	BERNERT	525	BEJ8	0.06	ALONG TANNER RD UNDER GREENE STREET	1.50	100	HW45	CONC	CIRC	0.250	25.7	P	10.9	18.8	NO	NO	14.8	22.7	NO	NO
35	BERNERT	526	BEJ9	0.019	AT TANNLER AND REMINGTON	1.25	83	HW90	CONC	CIRC	0.060	12.5	P	6.4	6.4	NO	NO	7.3	7.3	NO	NO
36	BERNERT	527	BEJ6	0.128	UNDER SALAMO AT TANNER DR.	2.00	390	HW45	CONC	CIRC	0.019	70.8	P	31.6	33.6	NO	NO	35.9	44.2	NO	NO
37	BERNERT	528	BEJ6	0.128	UNDER I-205	3.00	538	HW90	CMP	CIRC	0.026	35.9	C	31.6	33.6	NO	NO	35.9	44.2	NO	YES
38	BERNERT	529	BER5-5W1	0.224	UNDER 10TH	1.25	150	HW90	CONC	CIRC	0.040	70.8	C	72.0	74.6	YES	YES	84.7	87.5	YES	YES
39	BERNERT	530	BEJ4	0.528	NR 7TH	1.00	100	HW90	CONC	CIRC	0.050	25.7	C	166.0	171.5	YES	YES	192.4	199.5	YES	YES
40	BERNERT	531	BER3-4	0.528	UNDER WILLAMETTE FALLS DR NR 6TH ST.	1.25	160	PROJ	CMP	CIRC	0.040	92.5	C	165.7	171.3	YES	YES	191.9	199.0	YES	YES
41	BERNERT	532	BEJ3N1	0.124	UNDER WILLAMETTE FALLS DR AT 6TH ST.	3.50	90	HW45	CMP	CIRC	0.043	105.8	P	39.0	40.4	NO	NO	44.3	46.2	NO	NO
42	BERNERT	533	BEJ3N1	0.124	PAIR UNDER WILLAMETTE FALLS DR AT 6TH ST.	3.00	50	HW45	CONC	CIRC	0.132	25.7	P	39.0	40.4	YES	YES	44.3	46.2	YES	YES
43	BERNERT	534	BER2-3	0.682	UNDER 5TH AVENUE AT MOEHNKE ST.	2.00	37	PROJ	CONC	CIRC	0.076	49.9	C	213.2	220.6	YES	YES	245.6	254.5	YES	YES
44	BERNERT	535	BER2-2W1	0.111	UNDER 4TH ST. NR OUTFALL	1.50	45	PROJ	CONC	CIRC	0.016	66.0	C	21.7	31.9	NO	NO	25.8	36.8	NO	NO
45	BOLTON	590	BOR2-3	0.134	PIPE FROM HWY 43 TO HOLMES ST S. OF BUCK	1.75	520	HW45	CONC	CIRC	0.052	23.4	P	35.0	42.8	YES	YES	40.8	49.0	YES	YES
46	BOLTON	591	BOJ3	0.134	PIPE FROM HWY 43 TO FAILING ST. S. OF BUCK	2.50	250	HW45	CONC	CIRC	0.065	28.5	P	35.1	42.9	YES	YES	40.9	49.1	YES	YES
47	BOLTON	592	BOJ3	0.134	UNDER HIGHWAY 43 AT WEST A ST.	2.67	90	HW90	CONC	BOX	0.001	81.9	C	35.1	42.9	NO	NO	40.9	49.1	NO	NO
48	BOLTON	593	BOJ4	0.108	PIPE ALONG HWY 43 AT WEST A ST.	2.00	228	HW45	CONC	CIRC	0.036	25.7	P	27.2	34.5	YES	YES	31.9	39.6	YES	YES
49	BOLTON	594	BOJ5	0.083	UNDER CAUFIELD ST.	2.25	61	PROJ	CONC	CIRC	0.033	49.9	C	20.8	26.2	NO	NO	24.3	30.1	NO	NO
50	BOLTON	595	BOJ6	0.064	UNDER FIRWOOD CT.	2.00	230	PROJ	CONC	CIRC	0.130	20.5	C	16.5	20.2	NO	NO	19.3	23.2	NO	YES
51	BOLTON	596	BOJ7	0.042	UNDER SKYLINE DR NR. WOODWINDS CT.	2.50	140	PROJ	CMP	CIRC	0.057	22.8	C	9.6	12.3	NO	NO	11.3	14.2	NO	NO
52	CASCADE SPRINGS	475	CSJ3	0.036	DOWNSTREAM OF MCKILLICAN ST.	1.50	250	HW45	CONC	CIRC	0.011	25.5	P	10.7	11.5	NO	NO	12.4	13.2	NO	NO
53	CASCADE SPRINGS	574	CSJ4	0.027	PIPE ALONG MCKILLICAN FROM WEST A ST. TO	2.00	975	HW45	CONC	CIRC	0.105	12.5	P	7.7	8.4	NO	NO	9.0	9.6	NO	NO
54	CASCADE SPRINGS	575	CSJ3	0.036	UNDER PORTLAND AVENUE AT MCKILLICAN	2.50	167	HW45	CONC	CIRC	0.071	12.5	P	10.7	11.5	NO	NO	12.4	13.2	NO	YES
55	CASCADE SPRINGS	576	CSJ2	0.086	CULVERT UNDER RIVER STREET	2.00	60	PROJ	CONC	CIRC	0.142	48.2	C	26.5	29.4	NO	NO	30.6	33.7	NO	NO
56	DOLLAR	520	DOJ1	0.123	OUTFALL PIPE	2.00	325	HW45	CMP	CIRC	0.110	12.7	P	30.4	35.0	YES	YES	35.1	40.1	YES	YES
57	DOLLAR	521	DOJ2	0.089	ALONG BORLAND FROM OSTMAN TO OUTFALL PIPE	2.00	1200	HW45	CONC	CIRC	0.037	25.7	P	24.9	27.0	NO	YES	28.9	30.9	YES	YES
58	DOLLAR	522	DOJ3	0.049	FROM BEXHILL TO BORLAND	1.50	420	HW45	CONC	CIRC	0.053	25.7	P	13.5	14.7	NO	NO	15.7	16.8	NO	NO
59	FERN	434	FNJ2-ARJ1	0.994	CULVERTS NR ARBOR DRIVE (8", 12", 30" UNDER PVT.	#N/A	20	PROJ	CMP	CIRC	0.010	25.5	C	197.6	215.0	YES	YES	228.4	247.7	YES	YES
60	FERN	500	FNJA	0.065	PAIR UNDER CARRIAGE WAY	2.00	100	PROJ	CONC	CIRC	0.050	23.8	C	11.7	10.4	NO	NO	15.6	14.8	NO	NO
61	FERN	500	FNJA	0.065	PAIR UNDER CARRIAGE WAY	2.00	100	PROJ	CONC	CIRC	0.050	20.6	C	11.7	10.4	NO	NO	15.6	14.8	NO	NO
62	FERN	636	FNJ7	0.196	CULVERT NR KANTARA WAY	3.50	65	PROJ	CONC	CIRC	0.108	28.6	C	30.2	31.0	YES	YES	39.7	41.1	YES	YES
63	FERN	637	FNJ7	0.196	NEAR KANTARA WAY	3.50	28	PROJ	CMP	CIRC	0.071	20.3	C	30.2	31.0	YES	YES	39.7	41.1	YES	YES
64	FERN	638	FNJ6	0.224	UNDER PACIFIC HIGHWAY NR NORHT END OF	2.67	400	HW45	CONC	CIRC	0.033	104.1	P	33.5	37.6	NO	NO	44.8	46.8	NO	NO
65	FERN	639	FNR6-7	0.196	ENTRANCE PIPE TO SYSTEM UNDER PACIFIC	3.00	85	HW90	CONC	CIRC	0.076	104.1	C	29.9	30.9	NO	NO	39.6	41.0	NO	NO
66	FERN	640	FNJ5	0.233	CULVERT UNDER ROSE WAY	2.67	205	PROJ	CONC	CIRC	0.044	51.2	C	35.8	40.0	NO	NO	46.4	48.4	NO	NO
67	FERN	641	FNR4-5	0.233	PAIR CULVERTS NR INTERSECTION OF OLD RIVER	5.00	30	PROJ	CMP	CIRC	0.010	26.5	C	35.8	40.0	YES	YES	46.0	48.0	YES	YES
68	FERN	641	FNR4-5	0.233	PAIR CULVERTS NR INTERSECTION OF OLD RIVER	2.75	30	PROJ	CMP	CIRC	0.010	26.5	C	35.8	40.0	YES	YES	46.0	48.0	YES	YES
69	FERN	656	FNJ1	1.042	CULVERT UNDER OLD RIVER ROAD	#N/A	71	PROJ	CMP	CIRC	0.127	133.6	C	202.9	220.4	YES	YES	234.1	253.5	YES	YES
70	FRITCHIE	438	FRJ1S3	0.051	UNDER KILARNEY AT LIMERICK	1.25	680	HW45	CMP	CIRC	0.082	6.5	P	12.5	15.3	YES	YES	14.7	17.6	YES	YES
71	FRITCHIE	439	FRJ1S3	0.051	UNDER DEBOK	3.00	60	HW45	CONC	CIRC	0.167	24.4	P	12.5	15.3	NO	NO	14.7	17.6	NO	NO
72	FRITCHIE	440	FR1S2	0.046	UNDER TAMARISK DR	2.00	388	HW45	CONC	CIRC	0.119	2.6	P	12.3	14.5	YES	YES	14.3	16.6	YES	YES
73	FRITCHIE	441	FR1S2	0.046	AT TAMARISK DRIVE	5.00	166	HW45	CONC	CIRC	0.060	6.4	P	12.3	14.5	YES	YES	14.3	16.6	YES	YES
74	FRITCHIE	442	FR1S2	0.046	AT WISTERIA CT.	4.00	327	HW45	CONC	CIRC	0.040	4.9	P	12.3	14.5	YES	YES	14.3	16.6	YES	YES
75	FRITCHIE	506	FRJ2	0.494	PAIR UNDER JOHNSON RD.	1.25	80	PROJ	CONC	CIRC	0.001	18.7	C	53.9	58.0	YES	YES	62.4	67.0	YES	YES
76	FRITCHIE	506	FRJ2	0.494	PAIR UNDER JOHNSON RD.	1.25	80	PROJ	CONC	CIRC	0.001	18.7	C	53.9	58.0	YES	YES	62.4	67.0	YES	YES
77	FRITCHIE	507	FRR2-3	0.467	DOWNSTREAM OF I-205, UNDER PRIVATE	2.50	17	PROJ	CONC	CIRC	0.018	160.8	C	50.6	54.0	NO	NO	58.4	62.4	NO	NO
78	FRITCHIE	508	FRJ1S1	0.112	ALONG JOHNSON RD	1.00	155	PROJ	CONC	CIRC	0.060	35.9	C	29.0	34.7	NO	NO	34.0	39.8	NO	YES
79	FRITCHIE	509	FRJ1S2	0.097	UNDER I-205	2.00	400	PROJ	CMP	CIRC	0.025	14.7	C	24.7	29.8	YES	YES	29.0	34.2	YES	YES
80	FRITCHIE	510	FRJ3	0.467	UNDER I-205 NR JOHNSON RD.	5.00	480	PROJ	CONC	CIRC	0.021	74.5	C	50.6	54.0	NO	NO	58.4	62.4	NO	NO
81	GANS	491	GSJ5	0.033	PIPE SYSTEM BETWEEN WILDWOOD DR AND HIDDEN	1.50	800	HW45	CONC	CIRC	0.225	25.7	P	10.3	10.3	NO	NO	11.8	11.8	NO	NO
82	GANS	621	GSJ4	0.077	SYSTEM UNDER COTTONWOOD DRIVE	1.50	125	PROJ	CONC	CIRC	0.197	13.9	P	24.0	23.3	YES	YES	27.6	26.9	YES	YES
83	GANS	622	GSJ4	0.077	ENTRANCE PIPE FOR SYSTEM NR HIDDEN SPRINGS	2.50	400	PROJ	CMP	CIRC	0.120	62.9	C	24.0	23.3	NO	NO	27.6	26.9	NO	NO
84	GANS	622	GSJ3	0.114	PIPE SYSTEM UNDER PACIFIC HIGHWAY	2.00	60	HW45	CONC	CIRC	0.022	70.8	P	36.5	35.8	NO	NO	41.8	41.2	NO	NO
85	GANS	623	GSJ4	0.077	CULVERT U/S OF ROBINWOOD APT.	1.50	50	PROJ	CONC	CIRC	0.089	49.9	C	24.0	23.3	NO	NO	27.6	26.9	NO	NO
86	GANS	624	GSJ2	0.13	PIPE SYSTEM FROM KNETHORPE TO CEDAR OAK	3.00	685	PROJ	CONC	CIRC	0.039	78.7	C	40.1	39.4	NO	NO	45.9	45.3	NO	NO
87	GANS	625	GSR2-3	0.114	PAIR UPSTREAM OF KENTHORPE WAY	3.00	25	PROJ	CONC	CIRC	0.004	7.2	C	36.4	35.7	YES	YES	41.7	41.0	YES	YES
88	HIDDEN SPRINGS	492	HSJ3	0.051	PIPE FROM DERBY ST TO BELLEVUE WAY	1.50	460	HW45	CMP	CIRC	0.030	21.4	P	14.8	13.2	NO	NO	16.9	15.3	NO	NO
89	HIDDEN SPRINGS	493	HSJ3	0.051	PIPE FROM BELLEVUE TO CARRIAGE WAY	3.00	445	HW45	CMP	CIRC	0.043	25.4	P	14.8	13.2	NO	NO	16.9	15.3	NO	NO
90	HIDDEN SPRINGS	614	HSJ1	0.088	PIPE UNDER BLUEGRASS WAY	2.25	145	HW45	CMP	CIRC	0.359	45.6	P	25.9	24.1	NO	NO	29.8	27.9	NO	NO
91	HIDDEN SPRINGS	615	HSR1-2	0.071	PIPE SYSTEM UNDER HIDDEN SPRINGS	2.00	225	HW45	CONC	CIRC	0.067	34.5	P	20.3	18.7	NO	NO	23.3	21.7	NO	NO
92	HIDDEN SPRINGS	616	HSR1-2	0.071	PIPE SYSTEM UNDER HIDDEN SPRINGS	2.00	285	HW45	CONC	CIRC	0.081	34.5	P	20.3	18.7	NO	NO	23.3	21.7	NO	NO
93	HIDDEN SPRINGS	617	HSJ2	0.071	PIPE FROM CARRIAGE WAY TO NR ASCOT CIRCLE	2.00	420	HW45	CONC	CIRC	0.079	25.7	P	20.3	18.7	NO	NO	23.3	21.7	NO	NO
94	MADDAX	476	MXJ4	0.039	PIPE SYSTEM UNDER WEST A ST.	2.00	130	HW90	CONC	CIRC	0.015	25.7	P	7.1	7.4	NO	NO	8.2	8.5	NO	NO
95	MADDAX	477	MXJ4	0.039	PIPE SYSTEM UNDER WEST A ST.	2.00	249	HW90	CONC	CIRC	0.006	19.1	P	7.1	7.4	NO	NO	8.2	8.5	NO	NO
96	MADDAX	478	MXJ4	0.039	PIPE SYSTEM UNDER WEST A ST.	2.00	72	HW90	CONC	CIRC	0.006	18.3	P	7.1	7.4	NO	NO	8.2	8.5	NO	NO
97	MADDAX	479	MXJ3S1	0.048	FROM SKYLINE DRIVE TO WEST A ST.	1.50	300	HW90	CONC	CIRC	0.060	12.5	P	4.3	4.3	NO	NO	5.0	5.0	NO	NO
98	MADDAX	480	MXJ3S1	0.048	FROM SKYLINE DRIVE TO WEST A ST.	1.50	354	HW90	CONC	CIRC	0.082	12.5	P	4.3	4.3	NO	NO	5.0	5.0	NO	NO
99	MADDAX	577	MXR3-4	0.039	UNDER POORTLAND AVENUE	1.50	280	HW45	CONC	CIRC	0.061	34.5	P	7.1	7.4	NO	NO	8.1	8.5	NO	NO
100	MADDAX	578	MXR3-4	0.039	UNDER BROADWAY	3.50	58	PROJ	CMP	CIRC	0.086	7.0	C	7.1	7.4	YES	YES	8.1	8.5	YES	YES
101	MADDAX	579	MXJ4	0.039	PIPE SYSTEM UNDER WEST A ST.	1.25	141	HW90	CONC	CIRC	0.001	9.3	P	7.1	7.4	NO	NO	8.2	8.5	NO	NO
102	MADDAX	580	MXJ4	0.039	PIPE SYSTEM UNDER WEST A ST.	2.25	246	HW90	CONC	CIRC	0.085	25.7	P	7.1	7.4	NO	NO	8.2	8.5	NO	NO
103	MADDAX	581	MXJ3	0.15	ALONG PORTLAND AVENUE FROM LEWIS TO BOLTON	1.50	290	HW45	CONC	CIRC	0.003	64.2	P	24.7	30.6	NO	NO	28.7	35.0	NO	NO
104	MADDAX	582	MXR2-3	0.15	PIPE ALONG PORTLAND AVENUE	1.75	90	HW45	CONC	CIRC	0.111	70.8	P	24.7	30.5	NO	NO	28.6	35.0	NO	NO
105	MADDAX	583	MXR3-3S1	0.048	UNDER PORTLAND AVENUE	2.00	165	HW45	CMP	CIRC	0.036	23.4	P	4.3	4.3	NO	NO	5.0	5.0	NO	NO
106	MADDAX	584	MXR3-3S1	0.048	ALONG PORTLAND AVENUE SOUTH SIDE	3.00	230	HW45	CONC	CIRC	0.007	19.8	P	4.3	4.3	NO	NO	5.0	5.0	NO	NO
107	MADDAX	585	MXR3-3S1	0.048	FROM BROADWAY TO PORTLAND AVENUE	2.00	405	HW45	CONC	CIRC	0.137	25.7	P	4.3	4.3	NO	NO	5.0	5.0	NO	NO
108	MADDAX	586	MXR3-3S1	0.048	FROM WEST A TO BROADWAY	2.00	503	HW45	CONC	CIRC	0.064	12.5	P	4.3	4.3	NO	NO	5.0	5.0	NO	NO
109	MADDAX	587	MXJ3S1	0.048	FROM SKYLINE DRIVE TO WEST A ST.	2.00	240	HW90	CONC	CIRC	0.092	8.8	P	4.3	4.3	NO	NO	5.0	5.0	NO	NO
110	MADDAX	588	MXJ2	0.181	UNDER RIVER ST.	1.75	50	PROJ	CMP	CIRC	0.096	16.3	C	32.9	40.2	YES	YES	38.2	46.0	YES	YES
111	MADDAX	589	MXR2-3	0.15	NR BURNS ST. UNDER PRIVATE DR.	2.00	35	PROJ	CONC	CIRC	0.143	28.6	C	24.7	30.5	NO	YES	28.6	35.0	YES	YES
112	MARY S YOUNG	482	MYJ5N1	0.048	PIPE UNDER PIMLICO DR.	2.00	275	HW45	CONC	CIRC	0.185	11.8	P	13.6	13.6	YES	YES	15.7	15.7	YES	YES
113	MARY S YOUNG	483	MYJ6	0.056	PIPE UNDER POSEIDON CT.	4.00	750	HW45	CONC	CIRC	0.116	32.5	P	16.0	16.2	NO	NO	18.5	18.7	NO	NO
114	MARY S YOUNG	484	MYJ5	0.141	PIPE UNDER POSEIDON CT.	4.00	700	HW45	CONC	CIRC	0.116	25.7	P	40.4	40.6	YES	YES	46.6	46.8	YES	YES
115	MARY S YOUNG	605	MYJ5	0.141	UNDER SUMMIT DR AT PIMLICO DR.	5.00	120	PROJ	CMP	CIRC	0.100	129.1	C	40.4	40.6	NO	NO	46.6	46.8	NO	NO
116	MARY S YOUNG	606	MYJ4S2	0.069	PIPE SYSTEM UNDER APOLLO	2.50	130	HW90	CONC	CIRC	0.015	25.7	P	12.7	18.8	NO	NO	15.2	21.6	NO	NO
117	MARY S YOUNG	607	MYJ4S2	0.069	PIPE SYSTEM UNDER APOLLO	3.00	100	HW90	CONC	CIRC	0.079	25.7	P	12.7	18.8	NO	NO	15.2	21.6	NO	NO
118	MARY S YOUNG	608	MYJ4S2	0.069	ENTRANCE TO PIPE SYSTEM UNDER APOLLO RD.	1.50	154	PROJ	CMP	CIRC	0.091	39.9	C	12.7	18.8	NO	NO	15.2	21.6	NO	NO
119	MARY S YOUNG	609	MYJ4S2	0.069	CULVERT UNER SUMMIT DR.	3.00	290	PROJ	CMP	CIRC	0.162	62.9	C	12.7	18.8	NO	NO	15.2	21.6	NO	NO
120	MARY S YOUNG	610	MYJ4	0.334	UNDER HIGHWAY 43 AT PIMLICO DR.	2.67	120	HW90	CONC	BOX	0.001	162.9	C	76.0	88.5	NO	NO	89.9	103.5	NO	NO
121	MARY S YOUNG	611	MYJ3	0.387	UNDER JOLIE POINTE	2.50	65	PROJ	CMP	CIRC	0.305	129.1	C	87.5	101.1	NO	NO	103.4	117.6	NO	NO
122	MCLEAN	474	MCJ2	0.339	PIPE ALONG I-205	1.50	110	PROJ	CONC	CIRC	0.070	102.4	P	85.0	85.2	NO	NO	97.9	98.0	NO	NO
123	MCLEAN	505	MCJ8	0.034	PIPE ALONG OREGON CITY BLVD.	2.00	250	HW45	CONC	CIRC	0.080	12.5	P	10.2	10.2	NO	NO	11.8	11.8	NO	NO
124	MCLEAN	564	MCJ7	0.07	PIPE ALONG OREGON CITY BLVD.	1.00	740	HW45	CONC	CIRC	0.106	25.7	P	15.6	15.6	NO	NO	17.9	17.9	NO	NO
125	MCLEAN	565	MCJ6	0.085	PIPE ALONG OREGON CITY BLVD.	1.33	95	HW45	CONC	CIRC	0.013	25.7	P	20.5	20.5	NO	NO	23.5	23.5	NO	NO
126	MCLEAN	566	MCJ5	0.122	NEAR H.S. TRACK	1.50	235	HW45	CONC	CIRC	0.004	2.5	P	26.9	26.9	YES	YES	31.3	31.3	YES	YES
127	MCLEAN	567	MCJ3W2	0.076	CULVERT UNDER MAPLE NR WALNUT ST.	1.75	90	PROJ	CMP	CIRC	0.044	8.3	C	15.3	14.8	YES	YES	17.8	17.2	YES	YES
128	MCLEAN	568	MCJ3W1	0.112	PIPE ALONG I-205	2.00	70	HW45	CMP	CIRC	0.700	8.3	P	26.7	26.8	YES	YES	30.8	30.9	YES	YES
129	MCLEAN	569	MCR3-4	0.141	PIPE ALONG I-205	3.33	816	HW45	CMP	CIRC	0.017	47.4	P	29.5	29.5	NO	NO	34.1	34.1	NO	NO
130	MCLEAN	570	MCR3-3W1	0.112	PIPE ALONG I-205	3.00	602	HW45	CMP	CIRC	0.027	20.0	P	26.7	26.8	YES	YES	30.8	30.9	YES	YES
131	MCLEAN	571	MCJ3W1	0.112	PIPE ALONG I-205	3.00	458	HW45	CMP	CIRC	0.028	5.5	P	26.7	26.8	YES	YES	30.8	30.9	YES	YES
132	MCLEAN	572	MCR2-3	0.299	PIPE ALONG I-205	3.50	970	HW45	CMP	CIRC	0.051	72.0	P	70.6	70.8	NO	NO	81.6	81.7	YES	YES
133	MCLEAN	573	MCJ2	0.339	PIPE ALONG I-205	2.00	375	HW45	CONC	CIRC	0.021	104.1	P	85.0	85.2	NO	NO	97.9	98.0	NO	NO
134	ROBIN	485	RBJ2S2	0.037	SYSTEM UNDERWILDERNESS DRIVE	1.50	125	PROJ	CONC	CIRC	0.560	11.3	P	9.6	9.7	NO	NO	11.2	11.3	NO	NO
135	ROBIN	486	RBJ2S2	0.037	SYSTEM UNDERWILDERNESS DRIVE	1.50	215	PROJ	CONC	CIRC	0.088	9.4	P	9.6	9.7	YES	YES	11.2	11.3	YES	YES
136	ROBIN	487	RBJ2S2	0.037	SYSTEM UNDERWILDERNESS DRIVE	1.50	92	PROJ	CONC	CIRC	0.109	13.9	P	9.6	9.7	NO	NO	11.2	11.3	NO	NO
137	ROBIN	488	RBJ2S2	0.037	SYSTEM UNDERWILDERNESS DRIVE	3.00	290	PROJ	CONC	CIRC	0.093	13.9	P	9.6	9.7	NO	NO	11.2	11.3	NO	NO
138	ROBIN	489	RBJ2S2	0.037	ENTRANCE TO SYSTEM UNDERWILDERNESS DRIVE	2.00	165	PROJ	CONC	CIRC	0.152	13.9	C	9.6	9.7	NO	NO	11.2	11.3	NO	NO
139	ROBIN	490	RBJ3	0.062	PIPE SYSTEM UNDER WALLING CIRCLE	1.25	90	HW45	CONC	CIRC	0.027	12.5	P	14.7	16.6	YES	YES	17.1	19.4	YES	YES
140	ROBIN	490	RBJ3	0.062	PIPE SYSTEM UNDER WALLING CIRCLE	1.50	90	HW45	CONC	CIRC	0.027	11.8	P	14.7	16.6	YES	YES	17.1	19.4	YES	YES
141	ROBIN	628	RBJ2S1	0.073	CULVERT UNDER HWY 43 S. OF WALLING	2.25	100	HW90	CONC	CIRC	0.098	253.8	C	19.7	20.7	NO	NO	23.0	24.2	NO	NO
142	ROBIN	629	RBR3-4	0.035	UNDER KANTARA LN.	2.50	30	PROJ	CONC	CIRC	0.083	8.8	C	10.7	10.8	YES	YES	12.3	12.5	YES	YES
143	ROBIN	630	RBR3-4	0.035	ENTRANCE TO PIPE SYSTEM UNDER WALLING CIRCLE	5.00	305	PROJ	CONC	CIRC	0.121	13.9	C	10.7	10.8	NO	NO	12.3	12.5	NO	NO
144	ROBIN	631	RBJ3	0.062	UNDER PACIFIC HIGHWAY AT WALLING CIRCLE	1.50	72	HW90	CONC	CIRC	0.097	23.7	C	14.7	16.6	NO	NO	17.1	19.4	NO	NO
145	ROBIN	632	RBJ2	0.172	UNDER OLD RIVER RD.	1.50	66	HW90	CONC	CIRC	0.042	70.8	C	47.0	50.4	NO	NO	54.5	58.3	NO	NO
146	ROBINWOOD	498	RWJ1S1	0.026	PIPE SYSTEM BETWEEN VISTA CT AND ROSE CT.	2.00	230	HW45	CONC	CIRC	0.043	2.8	P	8.5	8.5	YES	YES	9.7	9.7	YES	YES
147	ROBINWOOD	499	RWJ1S1	0.026	END PIPE UNDER FAIRVIEW	4.00	100	HW90	CONC	CIRC	0.050	2.8	C	8.5	8.5	YES	YES	9.7	9.7	YES	YES
148	ROBINWOOD	642	RWJ1W2S1	0.068	UNDER PACIFIC HIGHWAY NR S. EXIT OF LAZY RIVER	1.00	98	HW45	CONC	CIRC	0.050	7.9	P	21.0	23.0	YES	YES	24.3	26.2	YES	YES
149	ROBINWOOD	643	RWJ1S1	0.026	ENTRANCE PIPE UNDER VISTA CT.	0.83	62	PROJ	CONC	CIRC	0.032	7.4	C	8.5	8.5	YES	YES	9.7	9.7	YES	YES
150	ROBINWOOD	644	RWJ1S1	0.026	UNDER RIVER RD	2.00	60	PROJ	CONC	CIRC	0.017	28.6	C	8.5	8.5	NO	NO	9.7	9.7	NO	NO
151	ROBINWOOD	645	RWJ1S1	0.026	UNDER RIVER RD NR ROSE CT	2.00	186	HW45	CONC	CIRC	0.038	2.9	P	8.5	8.5	YES	YES	9.7	9.7	YES	YES
152	ROBINWOOD	646	RWJ1W2	0.068	UNDER PACIFIC HIGHWAY NR N. EXIT OF LAZY RIVER	1.17	64	HW45	CONC	CIRC	0.025	25.7	P	21.0	23.0	NO	NO	24.3	26.2	NO	YES
153	ROBINWOOD	647	RWR1W2-1W3	0.04	ALONG PACIFIC HIGHWAY NR MARYLHURST DR.	1.25	50	HW45	CONC	CIRC	0.016	25.7	P	12.6	13.4	NO	NO	14.5	15.3	NO	NO
154	ROBINWOOD	648	RWR1W2-1W3	0.04	FROM LOWER MIDHILL TO PACIFIC HIGHWAY	2.00	380	HW45	CONC	CIRC	0.095	7.5	P	12.6	13.4	YES	YES	14.5	15.3	YES	YES
155	ROBINWOOD	649	RWR1W2-1W3	0.04	ENTRANCE TO PIPE SYSTEM AT UPPER MIDHILL	2.00	235	PROJ	CONC	CIRC	0.149	9.3	C	12.6	13.4	YES	YES	14.5	15.3	YES	YES
156	ROBINWOOD	650	RWJ1W3	0.04	CULVERT UNDER UPPER MIDHILL	1.50	57	PROJ	CONC	CIRC	0.093	13.9	C	12.6	13.4	NO	NO	14.5	15.3	YES	YES
157	ROBINWOOD	651	RWJ6	0.051	PIPE SYSTEM UNDER SYLVAN WAY	2.00	84	HW45	CMP	CIRC	0.024	15.9	P	13.8	13.5	NO	NO	15.9	16.0	YES	YES
158	ROBINWOOD	652	RWJ5	0.07	CULVERT UNDER MARYLHURST DR NR MARYLWOOD	2.00	86	PROJ	CMP	CIRC	0.042	22.8	C	18.5	18.3	NO	NO	21.4	21.2	NO	NO
159	ROBINWOOD	653	RWJ4	0.102	CULVERT UNDER UPPER MIDHILL NR ROBINWOOD	1.50	75	PROJ	CMP	CIRC	0.120	15.9	C	24.4	25.7	YES	YES	28.3	29.8	YES	YES
160	ROBINWOOD	654	RWJ3	0.11	CULVERT UNDER PACIFIC HIGHWAY NRROBINWOOD	2.25	84	PROJ	CONC	CIRC	0.092	24.7	C	25.9	27.1	YES	YES	30.1	31.4	YES	YES
161	ROBINWOOD	655	RWJ2	0.128	CULVERT PAIR UNDER SHADY HOLLOW	1.50	68	PROJ	CONC	CIRC	0.091	33.5	C	30.0	32.2	NO	NO	35.0	37.3	YES	YES
162	ROBINWOOD	655	RWJ2	0.128	CULVERT PAIR UNDER SHADY HOLLOW	1.50	68	PROJ	CONC	CIRC	0.093	13.4	C	30.0	32.2	YES	YES	35.0	37.3	YES	YES
163	SALAMO	462	SAJ5N1	0.033	NR SALAMO RD AND VISTA RIDGE DR.	1.50	657	HW45	CONC	CIRC	0.115	4.5	P	7.2	7.2	YES	YES	9.6	9.6	YES	YES
164	SALAMO	463	SAJ5N1	0.033	NR SALAMO RD AND VISTA RIDGE DR.	2.50	50	HW45	CONC	CIRC	0.452	12.5	P	7.2	7.2	NO	NO	9.6	9.6	NO	NO
165	SALAMO	464	SAJ8	0.06	UNDER SALAMO INTO POND	3.17	90	HW45	CMP	CIRC	0.088	26.8	P	16.0	15.7	NO	NO	20.9	20.6	NO	NO
166	SALAMO	465	SAR5-6	0.132	SYSTEM UNDER SALAMO DR.	3.00	152	HW45	CONC	CIRC	0.005	60.7	P	26.0	29.9	NO	NO	33.1	39.0	NO	NO
167	SALAMO	466	SAR4-5	0.184	NR CRYSTAL TERRACE AND HASKINS	3.00	201	HW90	CONC	CIRC	0.010	70.8	P	34.2	40.8	NO	NO	45.3	53.9	NO	NO
168	SALAMO	467	SAR4-5	0.184	NR CRYSTAL TERRACE AND HASKINS	3.50	385	HW90	CONC	CIRC	0.050	50.0	P	34.2	40.8	NO	NO	45.3	53.9	NO	YES
169	SALAMO	542	SAJ8	0.06	ALONG SALAMO	3.00	650	HW90	CONC	CIRC	0.050	11.9	P	16.0	15.7	YES	YES	20.9	20.6	YES	YES
170	SALAMO	543	SAJ7	0.118	UNDER BLAND CR.	3.00	96	PROJ	CONC	CIRC	0.052	70.3	C	22.9	27.3	NO	NO	29.1	35.2	NO	NO
171	SALAMO	544	SAJ6	0.132	ALONG ROGUE WAY	3.00	530	HW90	CONC	CIRC	0.020	70.8	P	26.0	30.1	NO	NO	33.2	39.0	NO	NO
172	SALAMO	545	SAJ3	0.21	NR CRYSTAL TERRACE AND HASKINS	4.00	78	HW90	CONC	CIRC	0.035	0.0	P	36.6	46.5	YES	YES	48.6	61.3	YES	YES
173	SALAMO	546	SAJ3	0.21	UNDER BARRINGTON DR NR HASKINS LN.	1.75	120	HW45	CONC	CIRC	0.025	0.0	C	36.6	46.5	YES	YES	48.6	61.3	YES	YES
174	SALAMO	547	SAJ2	0.241	UNDER BEACON ILL DR. NR BARRINGTON DR.	2.00	150	HW45	CONC	CIRC	0.027	0.0	C	42.7	53.1	YES	YES	56.6	69.9	YES	YES
175	SUMMERLINN	435	SLJ3S1	0.049	JOHNSON RD. NR 19TH AVENUE	1.25	300	HW45	CONC	CIRC	0.013	5.1	P	13.3	14.4	YES	YES	15.3	16.5	YES	YES
176	SUMMERLINN	436	SL3S1	0.049	IN BLANKENSHIP DR	1.25	240	HW45	CONC	CIRC	0.057	5.6	P	13.3	14.4	YES	YES	15.3	16.5	YES	YES
177	SUMMERLINN	437	SLJ5N1	0.023	UNDER DEBOK AT VILLAGE PARK PL.	1.25	180	HW45	CMP	CIRC	0.094	3.5	P	7.5	7.1	YES	YES	8.6	8.2	YES	YES
178	SUMMERLINN	501	SLJ9	0.069	MATTERHORN COURT	1.25	119	HW90	CONC	CIRC	0.220	7.1	P	12.2	19.5	YES	YES	16.6	22.9	YES	YES
179	SUMMERLINN	502	SLJA	0.021	LUCERNE PALCE	0.83	240	HW90	CONC	CIRC	0.084	5.6	P	4.2	7.1	NO	YES	4.9	8.1	NO	YES
180	SUMMERLINN	503	SLJA	0.021	UNDER ALPINE DR	1.25	240	HW90	CONC	CIRC	0.070	5.6	P	4.2	7.1	NO	YES	4.9	8.1	NO	YES
181	SUMMERLINN	504	SLJA	0.021	ALONG CRESTVIEW FROM BLAND TO ALPINE	3.00	275	HW90	CONC	CIRC	0.087	1.9	P	4.2	7.1	YES	YES	4.9	8.1	YES	YES
182	SUMMERLINN	511	SLJ7	0.11	UNDER DEVELOPMENT AT VILLAGE PARK PLACE	2.00	115	HW90	CMP	CIRC	0.096	72.0	C	20.4	27.9	NO	NO	27.5	34.5	NO	NO
183	SUMMERLINN	512	SLJ7	0.11	UNDER DEVELOPMENT AT VILLAGE PARK PLACE	1.50	266	HW90	CMP	CIRC	0.080	28.3	C	20.4	27.9	NO	NO	27.5	34.5	NO	YES
184	SUMMERLINN	513	SLJ6	0.119	UNDER DEVELOPMENT AT VILLAGE PARK PLACE	3.00	73	HW90	CMP	CIRC	0.070	105.8	C	22.3	29.9	NO	NO	30.0	37.0	NO	NO
185	SUMMERLINN	514	SLJ5	0.16	FROM DEBOK TO I-205	3.00	300	HW45	CMP	CIRC	0.063	72.0	P	32.9	41.9	NO	NO	43.4	51.2	NO	NO
186	SUMMERLINN	515	SLJ4	0.186	UNDER I-205 NR 19TH ST.	3.50	440	HW45	CONC	CIRC	0.027	70.8	P	40.8	49.9	NO	NO	51.8	60.7	NO	NO
187	SUMMERLINN	516	SLJ2	0.313	UNDER RYAN CT.	3.00	125	PROJ	CMP	CIRC	0.018	191.9	C	81.0	89.2	NO	NO	93.0	107.0	NO	NO
188	SUMMERLINN	517	SLR1-2	0.313	UNDER MEADOWVIEW CT.	3.00	70	PROJ	CMP	CIRC	0.011	133.9	C	80.8	88.8	NO	NO	92.8	106.9	NO	NO
189	SUMMERLINN	518	SLR1-2	0.313	PAIR ALONG JOHNSON RD UNDER PRIVATE RD.	4.50	50	PROJ	CONC	CIRC	0.028	65.4	C	80.8	88.8	YES	YES	92.8	106.9	YES	YES
190	SUMMERLINN	518	SLR1-2	0.313	PAIR ALONG JOHNSON RD UNDER PRIVATE RD.	2.50	50	PROJ	CONC	CIRC	0.028	8.8	C	80.8	88.8	YES	YES	92.8	106.9	YES	YES
191	SUMMERLINN	519	SLR1-2	0.313	ALONG JOHNSON RD UNDER PRIVATE DRIVE	1.25	40	PROJ	CONC	CIRC	0.100	66.7	C	80.8	88.8	YES	YES	92.8	106.9	YES	YES

Appendix C

CULVERT AND PIPE INVENTORY WITH HYDRAULIC DEFICIENCIES

						Existing Structure								25-Year Design Flow (cfs)		Is it Deficient?		100-Year Design Flow (cfs)		Is it Deficient?	
Count	Watershed	PWR ID	HEC-HMS Subbasin	Drainage Area (mi^2)	Location / Description	Diam (ft)	Length (ft)	Inlet Type	Material	Shape	Slope (ft/ft)	Capacity (cfs)	Structure Type	Existing	Future	Now	Future	Existing	Future	Now	Future
192	SUNSET	468	SSR6-7	0.016	RUNNING PARALLEL TO BITTNER ST.	1.50	275	HW45	CONC	CIRC	0.051	7.9	P	3.7	4.8	NO	NO	4.4	5.6	NO	NO
193	SUNSET	470	SSJ7	0.016	PIPE UNDER EXETER STREET	2.00	180	HW45	CONC	CIRC	0.018	18.4	P	3.7	4.8	NO	NO	4.4	5.6	NO	NO
194	SUNSET	471	SSR6-7	0.016	PIPE UNDER LONG ST.	1.75	125	HW45	CONC	CIRC	0.208	9.3	P	3.7	4.8	NO	NO	4.4	5.6	NO	NO
195	SUNSET	472	SSJ6	0.061	UNDER CHARMAN ST.	1.25	81	PROJ	CMP	CIRC	0.025	19.3	C	18.4	19.9	NO	YES	21.3	22.8	YES	YES
196	SUNSET	473	SSR3-4	0.079	PIPE FROM SUNSET AVE. TO IMPERIAL DR.	2.00	250	HW90	CONC	CIRC	0.028	25.7	P	24.4	26.0	NO	YES	28.1	29.8	YES	YES
197	SUNSET	558	SSJ5	0.07	UNDER KELLEY STREET	1.33	60	PROJ	CMP	CIRC	0.050	22.8	C	21.5	23.1	NO	YES	24.8	26.5	YES	YES
198	SUNSET	559	SSJ4	0.079	ENTRANCE PIPE FROM SUNSET AVE. TO IMPERIAL DR.	2.00	412	HW90	CONC	CIRC	0.143	14.8	C	24.4	26.1	YES	YES	28.2	29.9	YES	YES
199	SUNSET	560	SSR3-4	0.079	FROM IMPERIAL DR. TO I-205	2.00	188	HW45	CONC	CIRC	0.128	25.3	P	24.4	26.0	NO	YES	28.1	29.8	YES	YES
200	SUNSET	561	SSJ3	0.101	UNDER I-205	2.00	172	HW45	CONC	CIRC	0.023	7.0	P	31.3	33.5	YES	YES	36.2	38.4	YES	YES
201	SUNSET	562	SSJ3	0.101	UNDER WILLAMETTE FALLS DR.	2.25	90	PROJ	CONC	CIRC	0.007	20.1	C	31.3	33.5	YES	YES	36.2	38.4	YES	YES
202	SUNSET	563	SSR1-2	0.109	CULVERT TO OUTFALL	1.25	420	PROJ	CONC	CIRC	0.075	28.6	C	34.1	36.3	YES	YES	39.4	41.6	YES	YES
203	TANNER	455	TAJ8W2	0.061	CHELAN DR TO PONDERAY DR.	3.00	179	HW45	CONC	CIRC	0.035	25.7	P	21.4	21.4	NO	NO	25.5	25.5	NO	NO
204	TANNER	456	TAR8W2-8W3	0.022	FROM BELKNAP TO CHELAN	2.00	278	HW45	CONC	CIRC	0.031	25.7	P	8.5	8.5	NO	NO	11.3	11.3	NO	NO
205	TANNER	457	TAJ8W3	0.022	FROM SALAMO TO BELKNAP	2.00	668	HW45	CONC	CIRC	0.032	25.7	P	8.9	8.9	NO	NO	11.5	11.5	NO	NO
206	TANNER	458	TAJ3E1	0.033	PIPE UNDER FAIRHAVEN DR	1.75	601	HW45	CONC	CIRC	0.080	7.9	P	8.5	10.0	YES	YES	10.0	11.5	YES	YES
207	TANNER	459	TAJF	0.035	NEW PIPE NR MIDDLE SCHOOL	1.75	339	HW90	CONC	CIRC	0.025	44.9	C	8.8	10.2	NO	NO	10.3	11.7	NO	NO
208	TANNER	460	TAJE	0.059	CULVERT UNDER DAY RD. NR HOOD CT.	2.00	76	PROJ	CONC	CIRC	0.011	45.7	P	13.3	14.2	NO	NO	15.6	16.4	NO	NO
209	TANNER	461	TAJB	0.122	PIPE UNDER PARKER RD.	2.50	150	HW90	CONC	CIRC	0.029	70.8	P	19.9	25.4	NO	NO	25.2	31.6	NO	NO
210	TANNER	536	TAJF	0.035	UNDER ROSEMONT NR PARKER RRD	2.50	50	PROJ	CONC	CIRC	0.118	20.5	C	8.8	10.2	NO	NO	10.3	11.7	NO	NO
211	TANNER	536	TAJF	0.035	UNDER ROSEMONT NR PARKER RRD	2.50	50	HW90	CONC	CIRC	0.118	18.4	C	8.8	10.2	NO	NO	10.3	11.7	NO	NO
212	TANNER	537	TAJC	0.098	CULVERT UNDER PARKER RD.	1.25	40	PROJ	CONC	CIRC	0.088	49.9	C	16.9	19.7	NO	NO	21.7	25.3	NO	NO
213	TANNER	538	TAJB	0.122	CULVERT UNDER PARKER RD	4.50	50	PROJ	CONC	CIRC	0.065	28.6	C	19.9	25.4	NO	NO	25.2	31.6	NO	YES
214	TANNER	539	TARA-B	0.122	CULVERT UNDER PATH	4.50	20	PROJ	CMP	CIRC	0.030	6.1	C	19.8	25.2	YES	YES	25.1	31.6	YES	YES
215	TANNER	540	TAJ8E1	0.079	UNDER PARKER RD NR COHO LN	1.00	65	HW45	CONC	CIRC	0.054	25.7	C	11.3	23.5	NO	NO	14.9	28.5	NO	YES
216	TANNER	541	TAJ9E1	0.075	UNDER PARKER RD.	2.00	66	PROJ	CONC	CIRC	0.030	13.9	C	12.3	19.5	NO	YES	16.5	24.2	YES	YES
217	TANNER	548	TAJ5E1	0.042	UNDER FAIRHAVEN DR.	3.00	60	PROJ	CONC	CIRC	0.017	78.7	C	8.7	11.8	NO	NO	10.2	13.6	NO	NO
218	TANNER	549	TAJ5-SAJ1	0.93	CULVERTS BETWEEN PONDS	1.50	78	HW90	CMP	CIRC	0.004	66.2	C	164.3	203.0	YES	YES	210.2	263.2	YES	YES
219	TANNER	549	TAJ5-SAJ1	0.93	CULVERTS BETWEEN PONDS	6.00	78	HW90	CMP	CIRC	0.004	66.2	C	164.3	203.0	YES	YES	210.2	263.2	YES	YES
220	TANNER	549	TAJ5-SAJ1	0.93	CULVERTS BETWEEN PONDS	4.50	78	HW90	CMP	CIRC	0.004	66.2	C	164.3	203.0	YES	YES	210.2	263.2	YES	YES
221	TANNER	550	TAJ4E1	0.013	FROM WELLINGTON DR TO WELLINGTON CT.	2.00	325	HW45	CONC	CIRC	0.129	11.5	P	3.7	4.1	NO	NO	4.4	4.7	NO	NO
222	TANNER	551	TAR4-4E1	0.013	ALONG WELLINGTON CT.	1.25	82	HW45	CONC	CIRC	0.265	25.7	P	3.7	4.1	NO	NO	4.4	4.7	NO	NO
223	TANNER	552	TAR4-4E1	0.013	UNDER WELLINGTON CT.	2.50	50	HW45	CONC	CIRC	0.005	17.4	P	3.7	4.1	NO	NO	4.4	4.7	NO	NO
224	TANNER	553	TAR4-5	0.93	UNDER WELLINGTON CT.	8.50	100	PROJ	CMP	CIRC	0.005	162.6	C	164.0	202.6	YES	YES	210.1	262.7	YES	YES
225	TANNER	554	TAR3-3E1	0.033	PIPE FROM RADCLIFF TO IMPERIAL	5.00	83	HW90	CONC	CIRC	0.012	12.5	P	8.5	9.9	NO	NO	10.0	11.4	NO	NO
226	TANNER	555	TAR3-4	0.995	UNDER IMPERIAL DR	2.00	90	PROJ	CMP	CIRC	0.011	613.8	C	179.2	220.2	NO	NO	229.4	282.5	NO	NO
227	TANNER	556	TAJ2	1.076	CULVERT UNDER I-205 NR RADCLIFF CT.	5.00	502	HW90	CONC	BOX	0.001	194.5	C	195.7	242.9	YES	YES	250.6	306.4	YES	YES
228	TANNER	557	TAJ1	1.094	WILLMETTE FALLS DR TO OUTFALL	2.00	280	PROJ	CONC	CIRC	0.246	282.2	C	199.6	247.0	NO	NO	254.7	310.4	NO	YES
229	TRILLIUM	494	TRJ6	0.046	PIPE SYSTEM UNDER MAPLETON, OUTFALL TO POND	2.00	75	HW45	CONC	CIRC	0.009	105.9	P	93.0	96.4	NO	NO	107.5	111.6	YES	YES
230	TRILLIUM	612	TRRA-B	0.046	CULVERT UNDER PRIVATE DRIVE NR CLUB HOUSE	2.25	49	PROJ	CONC	CIRC	0.027	35.2	C	19.9	21.9	NO	NO	23.0	25.2	NO	NO
231	TRILLIUM	613	TRJA	0.046	PIPE UNDER SANTA ANITA DR.	2.00	150	PROJ	CONC	CIRC	0.053	36.2	C	29.8	33.7	NO	NO	34.3	38.8	NO	YES
232	TRILLIUM	618	TRJ7	0.046	UNDER PACIFIC HIGHWAY NR CHOW MEIN LN. (HAS	2.25	90	HW90	CONC	CIRC	0.111	44.9	C	90.0	93.5	YES	YES	103.7	108.1	YES	YES
233	TRILLIUM	619	TRJ6	0.046	PIPE BETWEEN MAPLETON AND POND	2.00	180	PROJ	CONC	CIRC	0.041	52.9	P	93.0	96.4	YES	YES	107.5	111.6	YES	YES
234	TRILLIUM	620	TRJ6	0.046	ENTRANCE PIPE TO SYSTEM UNDER MAPLETON DR.	2.50	75	HW90	CONC	CIRC	0.011	25.4	C	93.0	96.4	YES	YES	107.5	111.6	YES	YES
235	TRILLIUM	620	TRJ6	0.046	ENTRANCE PIPE TO SYSTEM UNDER MAPLETON DR.	2.50	75	HW90	CONC	CIRC	0.011	25.4	C	93.0	96.4	YES	YES	107.5	111.6	YES	YES
236	TRILLIUM	626	TRJ5	0.046	PAIR UNDER KENTHORPE WAY	3.00	50	PROJ	CONC	CIRC	0.056	20.2	C	51.6	108.0	YES	YES	119.3	124.9	YES	YES
237	TRILLIUM	626	TRJ5	0.046	PAIR UNDER KENTHORPE WAY	4.00	50	PROJ	CONC	CIRC	0.056	90.7	C	103.2	108.0	YES	YES	119.3	124.9	YES	YES
238	TRILLIUM	627	TRR4-5	0.046	THREE CULVERTS UNDER CEDAR OAK DR	1.75	50	PROJ	CONC	CIRC	0.028	44.2	C	103.2	107.8	YES	YES	119.2	124.8	YES	YES
239	TRILLIUM	627	TRR4-5	0.046	THREE CULVERTS UNDER CEDAR OAK DR	3.50	50	PROJ	CONC	CIRC	0.028	65.4	C	103.2	107.8	YES	YES	119.2	124.8	YES	YES
240	TRILLIUM	627	TRR4-5	0.046	THREE CULVERTS UNDER CEDAR OAK DR	2.50	50	PROJ	CONC	CIRC	0.028	65.4	C	103.2	107.8	YES	YES	119.2	124.8	YES	YES
241	TRILLIUM	633	TRJ3-RBJ1	0.046	NEW CULVERT -TRILLIUM DR AT GLEN TERRACE	3.00	85	PROJ	CONC	CIRC	0.035	147.2	C	201.4	211.7	YES	YES	232.6	244.5	YES	YES
242	TRILLIUM	634	TRJ2	0.046	THREE CULVERTS UNDER ELMRAN AVE NR TRILLIUM	3.00	90	PROJ	CONC	CIRC	0.007	36.4	C	211.9	224.0	YES	YES	244.8	258.7	YES	YES
243	TRILLIUM	634	TRJ2	0.046	THREE CULVERTS UNDER ELMRAN AVE NR TRILLIUM	4.50	90	PROJ	CONC	CIRC	0.007	36.4	C	211.9	224.0	YES	YES	244.8	258.7	YES	YES
244	TRILLIUM	634	TRJ2	0.046	THREE CULVERTS UNDER ELMRAN AVE NR TRILLIUM	2.50	90	PROJ	CONC	CIRC	0.007	36.4	C	211.9	224.0	YES	YES	244.8	258.7	YES	YES
245	TRILLIUM	635	TRR1-2	0.046	UNDER CALAROGA DR.	2.50	54	PROJ	CONC	CIRC	0.059	190.6	C	211.7	223.6	YES	YES	244.8	258.6	YES	YES

Note: Prior to project design all field conditions shall be verifiec

Appendix D
City of West Linn
SURFACE WATER MANAGEMENT PLAN
"Windshield" Survey Form

Area Name: **SFR-1 WILLAMETTE RESIDENTIAL**

Subbasin Area ID: __________ Area Size: 13.3 acres

Land Use Type: Single Family | Multi-Family
Industrial | School
Commercial (Strip/Shopping Center) | Arterial Street
Open Space (Wooded/Ballfield/Field) | Other Parking Area

Location: Center 14th Street, 5th Avenue, 5 block area

____

____

Photographs: Photo Roll #1 Photo No. #s 16-23

Roof Drains: Underground | To gutter | To impervious | To pervious

Catchbasins: Number of catchbasins 7 Density/acre 0.5

Type: Trap (approx. depth below invert) 1'
No trap
Curb opening

Size: Length 2 1/2 Width 1 ½ Diameter NA

Topography: Flat (<1%) | Moderate (1-3%) | Steep (>3%)

Street Data:

Overall Condition:	Good	Fair	Poor
Street Texture:	Smooth	Intermediate	Rough
Pavement Material:	Asphalt	Concrete	Unpaved
Gutter:	Asphalt	Concrete	None

Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale - 20
Extruded curb
Curb and gutter - 1

Parking Density: None | Light | Moderate | Heavy

Nearby sediment sources? (describe) None

____

____

Comments: ____

____

____

City of West Linn
SURFACE WATER MANAGEMENT PLAN
"Windshield" Survey Form

Area Name: **SFR – 2 REMINGTON DRIVE**
Subbasin Area ID: __________ Area Size: 26.2 acres

Land Use Type: Single Family | Multi-Family
Industrial | School
Commercial (Strip/Shopping Center) | Arterial Street
Open Space (Wooded/Ballfield/Field) | Other Parking Area

Location: Remington Drive between Salamo and Tanner

Photographs: Photo Roll #2 Photo No. #s 3-8

Roof Drains: Underground | To gutter | To impervious | To pervious

Catchbasins: Number of catchbasins : 37 Density/acre 1.4

Type: Trap (approx. depth below invert) - 1 1/2'
No trap
Curb opening

Size: Length 2 ½' Width 2' Diameter N/A

Topography: Flat (<1%) | Moderate (1-3%) | Steep (>3%)

Street Data:

Overall Condition: Good | Fair | Poor
Street Texture: Smooth | Intermediate | Rough
Pavement Material: Asphalt | Concrete | Unpaved
Gutter: Asphalt | Concrete
Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale
Extruded curb
Curb and gutter
Parking Density: None | Light | Moderate | Heavy

Nearby sediment sources? (describe) Some new construction

Comments: ____

City of West Linn
SURFACE WATER MANAGEMENT PLAN
"Windshield" Survey Form

Area Name: **SFR 3 CHAPARREL ROAD**
Subbasin Area ID: __________ Area Size: 19.2 acres

Land Use Type: Single Family | Multi-Family
Industrial | School
Commercial (Strip/Shopping Center) | Arterial Street
Open Space (Wooded/Ballfield/Field) | Other Parking Area

Location: Chaparrel Road area off of Ponderay Drive

____

____

Photographs: Photo Roll #2 Photo No. #9

Roof Drains: Underground | To gutter | To impervious | To pervious

Catchbasins: Number of catchbasins 33 Density/acre 1.7

Type: Trap (appox. depth below invert) - 1 ½'
No trap
Curb opening

Size: Length 2 ½' Width 2' Diameter NA

Topography: Flat (<1%) | Moderate (1-3%) | Steep (>3%)

Street Data:

Overall Condition:	Good	Fair	Poor
Street Texture:	Smooth	Intermediate	Rough
Pavement Material:	Asphalt	Concrete	Unpaved
Gutter:	Asphalt	Concrete	

Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale
Extruded curb
Curb and gutter

Parking Density: None | Light | Moderate | Heavy

Nearby sediment sources? (describe) Home construction

____

____

Comments: ____

____

____

City of West Linn
SURFACE WATER MANAGEMENT PLAN
“Windshield” Survey Form

Area Name: **SFR-4 PALOMINO WAY**
Subbasin Area ID: __________ Area Size: 45.4 acres

Land Use Type: Single Family | Multi-Family
Industrial | School
Commercial (Strip/Shopping Center) | Arterial Street
Open Space (Wooded/Ballfield/Field) | Other Parking Area

Location: Palomino Way and Pimlico

____

____

Photographs: Photo Roll #2 Photo No. #s 11-13

Roof Drains: Underground | To gutter | To impervious | To pervious

Catchbasins: Number of catchbasins : 40 Density/acre 0.9

Type: Trap (appox. depth below invert) - N/A
No trap
Curb opening

Size: Length 2 ¼’ Width 1 ¾’ Diameter NA

Topography: Flat (<1%) | Moderate (1-3%) | Steep (>3%)

Street Data:

Overall Condition: Good | Fair | Poor
Street Texture: Smooth | Intermediate | Rough
Pavement Material: Asphalt | Concrete | Unpaved
Gutter: Asphalt | Concrete
Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale
Extruded curb
Curb and gutter (rolled)
Parking Density: None | Light | Moderate | Heavy

Nearby sediment sources? (describe) ______________________________

____

____

Comments: ____

____

____

City of West Linn
SURFACE WATER MANAGEMENT PLAN
"Windshield" Survey Form

Area Name: **COM-1 WILLAMETTE BUSINESS DISTRICT**
Subbasin Area ID: __________ Area Size: 12.1 acres

Land Use Type:

Single Family	Multi-Family
Industrial	School
Commercial (Strip/Shopping Center)	Arterial Street
Open Space (Wooded/Ballfield/Field)	Other Parking Area

Location: Willamette Falls Drive from Dollar to 10th Street

____

____

Photographs: Photo Roll #1 Photo No. #s 24-26

Roof Drains: Underground To gutter To impervious To pervious

Catchbasins: Number of catchbasins 22 Density/acre 1.8

Type: Trap (appox. depth below invert) - 6"
No trap
Curb opening

Size: Length 2 1/2 Width 1 1/2 Diameter N/A

Topography: Flat (<1%) Moderate (1-3%) Steep (>3%)

Street Data:

Overall Condition:	Good	Fair	Poor	
Street Texture:	Smooth	Intermediate	Rough	
Pavement Material:	Asphalt	Concrete	Unpaved	
Gutter:	Asphalt	Concrete		
Street Drainage:	Roadside ditch (dirt or vegetated) Grass-lined swale Extruded curb Curb and gutter			
Parking Density:	None	Light	Moderate	Heavy

Nearby sediment sources? (describe) None

____

____

Comments: ____

____

____

City of West Linn
SURFACE WATER MANAGEMENT PLAN
"Windshield" Survey Form

Area Name: **COM-2 I-205 SHOPPING CENTER**
Subbasin Area ID: __________ Area Size: 7.6 acres

Land Use Type:

Single Family	Multi-Family
Industrial	School
Commercial (Strip/Shopping Center)	Arterial Street
Open Space (Wooded/Ballfield/Field)	Other Parking Area

Location: 10th Street and Blankenship Street, general commercial

____

____

Photographs: Photo Roll ______ Photo No. ______

Roof Drains: Underground | To gutter | To impervious | To pervious

Catchbasins: Number of catchbasins: 12 Density/acre 1.6

Type: Trap (appox. depth below invert) - 2'
No trap
Curb opening (Lynch Type 2'x2'x3' deep model)

Size: Length 2' Width 2' Diameter N/A

Topography: Flat (<1%) | Moderate (1-3%) | Steep (>3%)

Street Data:

Overall Condition:	Good	Fair	Poor
Street Texture:	Smooth	Intermediate	Rough
Pavement Material:	Asphalt	Concrete	Unpaved
Gutter:	Asphalt	Concrete	

Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale
Extruded curb
Curb and gutter Parking Lot

Parking Density: None Light Moderate Heavy

Nearby sediment sources? (describe) None

____

____

Comments: ~1/2 of catchbasins (inlets are area drains needing overland flow. The rest are along curbs and gutters on the ds. Side of topo.

____

City of West Linn
SURFACE WATER MANAGEMENT PLAN
“Windshield” Survey Form

Area Name: **COM-3 CITY HALL CENTER**
Subbasin Area ID: __________ Area Size: 14.4 acres

Land Use Type:

Single Family	Multi-Family
Industrial	School
Commercial (Strip/Shopping Center)	Arterial Street
Open Space (Wooded/Ballfield/Field)	Other Parking Area

Location: City Hall

____

____

Photographs: Photo Roll ______ Photo No. ______

Roof Drains: Underground To gutter To impervious To pervious

Catchbasins: Number of catchbasins: 30 Density/acre 2.1

Type: Trap (appox. depth below invert) - 2’
No trap
Curb opening (Lynch hooded)

Size: Length 2’ Width 2’ Diameter NA

Topography: Flat (<1%) Moderate (1-3%) Steep (>3%)

Street Data:

Overall Condition:	Good	Fair	Poor
Street Texture:	Smooth	Intermediate	Rough
Pavement Material:	Asphalt	Concrete	Unpaved
Gutter:	Asphalt	Concrete	

Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale
Extruded curb
Curb and gutter Parking Lot

Parking Density: None Light Moderate Heavy

Nearby sediment sources? (describe) Some vacant lots

____

____

Comments: ____

____

____

City of West Linn
SURFACE WATER MANAGEMENT PLAN
"Windshield" Survey Form

Area Name: **SFR-5 WINDSOR TERRACE**
Subbasin Area ID: __________ Area Size: 39.2 acres

Land Use Type: Single Family | Multi-Family
Industrial | School
Commercial (Strip/Shopping Center) | Arterial Street
Open Space (Wooded/Ballfield/Field) | Other Parking Area

Location: Windsor Terrace

Photographs: Photo Roll #2 Photo No. #s19-22

Roof Drains: Underground | To gutter | To impervious | To pervious

Catchbasins: Number of catchbasins: 28 Density/acre 0.7

Type: Trap (appox. depth below invert) - 1'
No trap
Curb opening

Size: Length 2 ½' Width 1 ½' Diameter N/A

Topography: Flat (<1%) | Moderate (1-3%) | Steep (>3%)

Street Data:

Overall Condition:	Good	Fair	Poor
Street Texture:	Smooth	Intermediate	Rough
Pavement Material:	Asphalt	Concrete	Unpaved
Gutter:	Asphalt	Concrete	

Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale
Extruded curb
Curb and gutter

Parking Density: None | Light | Moderate | Heavy

Nearby sediment sources? (describe) ____________________

Comments: ____________________

City of West Linn
SURFACE WATER MANAGEMENT PLAN
"Windshield" Survey Form

Area Name: **SFR-6 CEDAROAK PARK**
Subbasin Area ID: __________ Area Size: 54.4 acres

Land Use Type: Single Family | Multi-Family
Industrial | School
Commercial (Strip/Shopping Center) | Arterial Street
Open Space (Wooded/Ballfield/Field) | Other Parking Area

Location: Trillium Drive area

Photographs: Photo Roll #2 Photo No. #s22-25

Roof Drains: Underground | To gutter | To impervious | To pervious

Catchbasins: Number of catchbasins: 5 Density/acre 0.1

Type: Trap (appox. depth below invert) - N/A
No trap
Curb opening

Size: Length 2 ½' Width 1 ½' Diameter N/A

Topography: Flat (<1%) | Moderate (1-3%) | Steep (>3%)

Street Data:

Overall Condition: Good | Fair | Poor
Street Texture: Smooth | Intermediate | Rough
Pavement Material: Asphalt | Concrete | Unpaved
Gutter: None | Asphalt | Concrete
Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale
Extruded curb
Curb and gutter | Skinny street "cute little lane"
Parking Density: None | Light | Moderate | Heavy

Nearby sediment sources? (describe) ______________________________

Comments: ______________________________

City of West Linn
SURFACE WATER MANAGEMENT PLAN
"Windshield" Survey Form

Area Name: **COM-4 HWY 43 – ZUPAN'S**
Subbasin Area ID: __________ Area Size: 6.2 acres

Land Use Type:
Single Family | Multi-Family
Industrial | School
Commercial (Strip/Shopping Center) | Arterial Street
Open Space (Wooded/Ballfield/Field) | Other Parking Area

Location: Zupan's Shopping Center

____

____

Photographs: Photo Roll #3 Photo No. #s 1-3

Roof Drains: Underground Piping To gutter To impervious To pervious

Catchbasins: Number of catchbasins 9 Density/acre 1.5

Type: Trap (appox. depth below invert) - 2'
No trap
Curb opening (Lynch Type)

Size: Length 2' Width 2' Diameter N/A

Topography: Flat (<1%) Moderate (1-3%) Steep (>3%)

Street Data:

Overall Condition:	Good	Fair	Poor
Street Texture:	Smooth	Intermediate	Rough
Pavement Material:	Asphalt	Concrete	Unpaved
Gutter: None	Asphalt	Concrete	

Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale
Extruded curb
Curb and gutter Parking lot

Parking Density: None Light Moderate Heavy

Nearby sediment sources? (describe) ______________________________

____

____

Comments: ____

____

____

City of West Linn
SURFACE WATER MANAGEMENT PLAN
"Windshield" Survey Form

Area Name: **MULT-1 ROBINWOOD VILLAGE APT.**
Subbasin Area ID: __________ Area Size: 4.4 acres

Land Use Type:

Single Family	Multi-Family
Industrial	School
Commercial (Strip/Shopping Center)	Arterial Street
Open Space (Wooded/Ballfield/Field)	Other Parking Area

Location: Robinwood Village

____

____

Photographs: Photo Roll #3 Photo No. #s 4-9

Roof Drains: Underground-to piped system? To impervious To pervious

Catchbasins: Number of catchbasins 5 Density/acre 1.1

Type: Trap (appox. depth below invert) - 2'
No trap
Curb opening

Size: Length 1 ½' Width 2' Diameter N/A

Topography: Flat (<1%) Moderate (1-3%) Steep (>3%)

Street Data:

Overall Condition:	Good	Fair	Poor
Street Texture:	Smooth	Intermediate	Rough
Pavement Material:	Asphalt	Concrete	Unpaved

Gutter: None Asphalt Concrete

Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale
Extruded curb
Curb and gutter Parking Lot

Parking Density: None Light Moderate Heavy

Nearby sediment sources? (describe) ______________________________________

____

____

Comments: ____

____

____

City of West Linn
SURFACE WATER MANAGEMENT PLAN
"Windshield" Survey Form

Area Name: **MULT-2 TITAN AND SUNBURST TOWNHOUSES**
Subbasin Area ID: __________ Area Size: 6.1 acres

Land Use Type:

Single Family	Multi-Family
Industrial	School
Commercial (Strip/Shopping Center)	Arterial Street
Open Space (Wooded/Ballfield/Field)	Other Parking Area

Location: Titan Terrace Townhouses and Sunburst Terrace Townhouses

____

____

Photographs: Photo Roll #3 Photo No. #s 10-13

Roof Drains: Underground | To gutter | To impervious | To pervious

Catchbasins: Number of catchbasins 7 Density/acre 1.1

Type: Trap (appox. depth below invert) - N/A
No trap
Curb opening

Size: Length 2 ¼' Width 2 ¼' Diameter N/A

Topography: Flat (<1%) | Moderate (1-3%) | Steep (>3%)

Street Data:

Overall Condition:	Good	Fair	Poor
Street Texture:	Smooth	Intermediate	Rough
Pavement Material:	Asphalt	Concrete	Unpaved
Gutter: None	Asphalt	Concrete	

Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale
Extruded curb
Curb and gutter Parking Lot

Parking Density: None Light Moderate Heavy

Nearby sediment sources? (describe) ____

____

____

Comments: ____

____

____

City of West Linn
SURFACE WATER MANAGEMENT PLAN
"Windshield" Survey Form

Area Name: **MULT-3 HOODVIEW TOWNHOUSE**
Subbasin Area ID: __________ Area Size: 11.9 acres

Land Use Type:

Single Family	Multi-Family
Industrial	School
Commercial (Strip/Shopping Center)	Arterial Street
Open Space (Wooded/Ballfield/Field)	Other Parking Area

Location: Hoodview Estates Twonhouse

____

____

Photographs: Photo Roll #3 Photo No. #s 13-17

Roof Drains: Underground To gutter To impervious To pervious

Catchbasins: Number of catchbasins 14 Density/acre 1.2

Type: Trap (appox. depth below invert) - 1 1/2'
No trap
Curb opening

Size: Length 2 ½' Width 2' Diameter N/A

Topography: Flat (<1%) Moderate (1-3%) Steep (>3%)

Street Data:

Overall Condition:	Good	Fair	Poor
Street Texture:	Smooth	Intermediate	Rough
Pavement Material:	Asphalt	Concrete	Unpaved
Gutter:	Asphalt	Concrete	

Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale
Extruded curb
Curb and gutter

Parking Density: None Light Moderate Heavy

Nearby sediment sources? (describe) ______________________________

____

____

Comments: ____

____

____

City of West Linn
SURFACE WATER MANAGEMENT PLAN
"Windshield" Survey Form

Area Name: **MULT-4 CASCADE SUMMIT APARTMENTS**
Subbasin Area ID: __________ Area Size: 25.5 acres

Land Use Type:

Single Family	Multi-Family
Industrial	School
Commercial (Strip/Shopping Center)	Arterial Street
Open Space (Wooded/Ballfield/Field)	Other Parking Area

Location: Cascade Summit

____

____

Photographs: Photo Roll #3 Photo No. #s 18-20

Roof Drains: Underground pipes To gutter To impervious To pervious

Catchbasins: Number of catchbasins 38 Density/acre 1.5

Type: Trap (appox. depth below invert) - 2'
No trap
Curb opening

Size: Length 2' Width 2' Diameter N/A

Topography: Flat (<1%) Moderate (1-3%) Steep (>3%)

Street Data:

Overall Condition:	Good	Fair	Poor
Street Texture:	Smooth	Intermediate	Rough
Pavement Material:	Asphalt	Concrete	Unpaved
Gutter: None	Asphalt	Concrete	

Street Drainage: Roadside ditch (dirt or vegetated)
Grass-lined swale
Extruded curb
Curb and gutter Parking Lot

Parking Density: None Light Moderate Heavy

Nearby sediment sources? (describe) ____

____

____

Comments: ____

____

APPENDIX E
City of West Linn
Listing of Acronyms

BMP – Best Management Practice
CWA – Clean Water Act
EIA – Effective Impervious Area
EPA – Environmental Protection Agency
ESA – Endangered Species Act
FEMA – Federal Emergency Management Agency
FES – Fishman Environmental Services
FIS – Flood Insurance Study
GIS – Geographic Information System
HEC-HMS – Hydrologic Engineering Center's Hydrologic Modeling System
HSPF – Hydrocomp Simulation Program Fortran
LCDC – Land Conservation and Development Commission
MC – Muskingum-Cunge
MEP – Maximum Extent Practicable
MRCI – Municipal, Residential, Commercial, and Industrial
MS4 – Municipal Separate Storm Sewers Systems
NFIP – National Flood Insurance Program
NMFS – National Marine Fisheries Service
NOAA Fisheries – National Oceanic Atmospheric Administration Marine Fisheries Service
NPDES – National Pollution Discharge Elimination System
OAR – Oregon Administrative Rule
PRF – Pollutant Reduction Facility
PWFOA – People with Fear of Acronyms
PWR – Pacific Water Resources
RLIS – Regional Land Information System
SCS – Soil Conservation Service
SDC – System Development Charge
SFHA – Special Flood Hazard Area
SMA – Soil Moisture Accounting
SWMP – Storm Water Management Plan
TMDL – Total Maximum Daily Load
USB – Urban Services Boundary
USFWS – U.S. Fish and Wildlife Service

Appendix F
City of West Linn
Natural Resource Assessment

LOWER WILLAMETTE RIVER WATERSHED

FERN CREEK BASIN

Arbor Creek, Robinwood Creek, and Fern Creek

Arbor Creek (AR-R-1)
Tributary to Fern Creek

Location:	Fern Creek to Skye Parkway
Description:	Fish bearing stream flows through a forested ravine along the northern city limits, bordered by residential neighborhoods and Marylhurst University. Confluence with Fern Creek is near outfall to the Willamette River.
Fish bearing?	Yes
Fish barriers:	Culverts, large drop to Willamette River
Channel type:	Steep narrow valley channel
Bank/channel conditions:	Generally stable; some areas of erosion
Notes:	Good in-stream structure, nests in alder, young cedar regeneration.
Recommendations:	Restore gaps in vegetated riparian corridor to improve habitat and slope stabilization values. Pre-treat stormwater discharges and remove in-stream obstacles for fish passage. Manage invasive plant species.

FES Field Notes 10/29/02:

At Willamette Drive (Highway 43), good flow downstream, some bubbles indicate water quality concern, 1-foot drop and 1-foot plunge pool at culvert. English ivy very bad (heavy infestation), and Himalayan blackberry very invasive. Stream downcutting 3 feet, losing back yards.

Downstream: Public path, less steep gradient, no downcutting, into Troutdale Formation. Old culvert under old farm road could be removed for boardwalk (behind 2831 Arbor Drive).

Note that there is a fish barrier at Fern Creek – Willamette River outfall.

Robinwood Creek (RO-R-1)
Tributary to Fern Creek

Location:	Fern Creek confluence to Hillcrest
Description:	A diverse, densely vegetated corridor; Robinwood Creek emerges from a secluded hillside ravine, passes through a locally rare Oregon ash - slough sedge wetland, then enters a steep, forested canyon where it meets Fern Creek on city park land.
Fish bearing?	Potential
Fish barriers:	Culverts, large drop to Willamette River
Channel type:	Steep narrow valley channel
Bank/channel conditions:	Segments of eroded banks, incised channel
Notes:	Oak / madrone community on hillside rocky slopes
Recommendations:	Manage ivy and blackberry encroachment (City has started this work on future park lands). Explore options to improve terrestrial and aquatic habitat connectivity at road crossings.

Lower Fern Creek (FE-R-1)
Tributary to Willamette River

Location:	Willamette River to Walling Way
Description:	One of the longest uninterrupted stream reaches connected to the Willamette River in the City. Channel meanders along floodplain terrace bordered by steep forested slopes, then under Old River Road in a 4-foot culvert before cascading down a rocky ledge 30 feet to the river.
Fish bearing?	Yes (ODFW reports unidentified game fish)
Fish barriers:	None (Major drop to Willamette is limiting for salmonids)
Channel type:	Moderate gradient moderately confined channel
Bank/channel conditions:	Mostly stable, natural
Notes:	Unique, essentially continuous reach, well-connected riparian system.
Recommendations:	Remove English ivy from trees and ground surface; manage Himalayan blackberry and other invasives. Evaluate options to improve terrestrial and aquatic habitat connections to upper reaches.

FES Field Notes 10/29/02:

Fern Creek outfall at Old River Road. Four foot+ corrugated metal culvert under River Road; top is slightly crushed, no substrate in pipe. Some erosion occurring around the edges of the pipe so needs repair. Should be replaced with a box or arch concrete culvert. Upstream is well graveled and connects to floodplain bench. Outfall to the Willamette River: About a 20-foot drop to ordinary water level (river very low today) with two 8-10-foot jumps with no plunge pools = Fish Barrier.

Upper Fern Creek (FE-R-2)
Tributary to Willamette River

Location:	Highway 43 to Carriage Way Open Space
Description:	Long, generally continuous reach through a steep forested canyon with an emergent wetland and a small pond near headwaters. Corridor crosses a series of open space tracts.
Fish bearing?	Yes
Fish barriers:	Culverts
Channel type:	Steep narrow valley channel
Bank/channel conditions:	Moderately stable; natural / semi-natural
Notes:	Long segment without crossings
Recommendations:	Restore blackberry dominated clearings with native trees and shrubs. Explore stream daylighting opportunities in vicinity of Highway 43.

TRILLIUM CREEK BASIN

Robin Creek, Gans Creek, and Trillium Creek

Lower Robin Creek (RN-R-1)
Tributary to Trillium Creek

Location:	Trillium Creek to Carriage Way
Description:	Narrow, mostly wooded reach dominated by blackberry and ivy near homes and businesses; flows into Trillium Creek, which supports cutthroat trout.

Fish bearing?	Potential
Fish barriers:	Culverts
Channel type:	Steep narrow valley channel
Bank/channel conditions:	Generally stable
Notes:	Blackberry infested (hard to see stream)
Recommendations:	Manage invasives; buffer parking lots, roads, and homes with dense native shrubs.

Upper Robin Creek (RN-R-2)
Tributary to Trillium Creek

Location:	Walling Circle to Carriage Way
Description:	Steep gradient headwaters reach flows through forested Wildwood Open Space, then into a pipe near Walling Circle.
Fish bearing?	No
Fish barriers:	Culvert
Channel type:	Steep narrow valley channel
Bank/channel conditions:	Generally stable
Notes:	None
Recommendations:	Manage invasives; primarily in areas near roads and residences.

Gans Creek (GA-R-1)
Tributary to Trillium Creek

Location:	Kenthorpe Way to Highway 43
Description:	Small, narrow canyon in a residential neighborhood enters culverts and pipes before it reaches Trillium Creek.
Fish bearing?	No
Fish barriers:	Culverts
Channel type:	Moderately steep narrow valley channel
Bank/channel conditions:	Multiple crossings, degraded
Notes:	Off-site inventory from roads
Recommendations:	Restore streambed and riparian buffer; manage invasives.

FES Field Notes 10/29/02:

> At Robinwood Village apartments above Highway 43. Very small channel drainage flowing under culvert and through parking strips, between parking lot and buildings, then culverted for quite a distance.

Lower Trillium Creek (TR-R-1)
Tributary to Willamette River

Location:	Willamette River to Highway 43
Description:	Lower reach of perennial stream with multiple associated wetlands and ponds; supports cutthroat trout. Diverse habitat with housing encroaching on corridor in certain areas. Stream flows into 4-foot culvert with 6-inch drop under Calaroga Drive and through step pools before reaching Willamette River.
Fish bearing?	Yes Fish barriers: Culverts (limiting). Blockages under some flow conditions
Channel type:	Moderately steep narrow valley channel
Bank/channel conditions:	Good, incised in residential fill areas
Notes:	Diverse wetland habitats in lower segment
Recommendations:	Manage to preserve fish habitat and wetland complex. Remove and manage exotic invasives. Limit housing / road impacts.

FES Field Notes 10/29/02:

Downstream from Elmran Avenue 5-foot culvert with 1-foot drops, two weirs (concrete grade control structures approximately 2-feet wide across stream). First one is subbed under (eroded underneath), no pool, second one has a little jump. Downstream goes to bedrock. Upstream looks better.

Upper Trillium Creek (TR-R-2)
Tributary to Willamette River

Location:	Highway 43 to Rosemont Road
Description:	Well-vegetated upper reach originating in ash forest on school district lands and flowing through mixed forest in Hidden Springs open space.
Fish bearing?	Yes (cutthroat trout)
Fish barriers:	Culverts limiting
Channel type:	Moderately steep narrow valley channel
Bank/channel conditions:	Stable, well vegetated
Notes:	Relatively intact reach largely in open space; highest quality ridge canyon in City.
Recommendations:	Restore gaps in riparian corridor; plant native trees. Enhance connectivity at road crossings (including Highway 43), potentially using bridges.

HERON CREEK BASIN

Heron Creek

Lower Heron Creek (HE-R-1)
Tributary to Willamette River

Location:	Willamette River to Highway 43
Description:	Spring fed stream flows through forests of Mary S. Young State Park and into a steep canyon with mature hemlock and fir trees before passing residential area and making a steep descent into the Willamette River across from Cedar Island.

Fish bearing?	No
Fish barriers:	Culverts
Channel type:	Moderately steep narrow valley channel
Bank/channel conditions:	Good condition despite gradient
Notes:	Large patch with medium to large trees
Recommendations:	Remove ivy; re-vegetate with dense natives.

FES Field Notes 10/29/02:

In Mary S. Young State Park, very low gradient, stagnant. Culverted under paved trail (1-2 feet wide). Further upstream ~½-inch flow with a little gravel, ditched u-shaped channel.

Upper Heron Creek (HE-R-2)
Tributary to Willamette River

Location:	Larkspur to Pimlico Drive / Sorrel
Description:	Spring fed perennial headwater stream with small pond near source flows through forested ravine before entering pipe under Highway 43 development.
Fish bearing?	No
Fish barriers:	Pipe at end of reach
Channel type:	Moderately steep narrow valley channel
Bank/channel conditions:	Fair; blackberry dominant in upper reach
Notes:	Recruitment better at lower end; potential amphibian breeding
Recommendations:	Remove English ivy from firs (major problem).

TURKEY CREEK BASIN

Turkey Creek

Turkey Creek (TY-R-1)
Tributary to Willamette River

Location:	Willamette River to Mary S. Young State Park
Description:	Small, mostly forested basin within Mary S. Young Park. Stream drops through a steep canyon, an associated emergent wetland, and then into the Willamette River.
Fish bearing?	No
Fish barriers:	Not applicable
Channel type:	Steep narrow valley channel
Bank/channel conditions:	Natural and stable
Notes:	Subbasin has minimal impervious surfaces
Recommendations:	Manage invasive species. Trail culverts could potentially be improved for fish and wildlife access.

FES Field Notes 10/29/02:

In Mary S. Young State Park, very small outflow, channelized through park, has pond (headwater seep area) adjacent to trail with a flat concrete outflow, definitely a fish barrier.

MARY S. YOUNG CREEK BASIN

Mary S. Young Creek

Lower Mary S. Young Creek (MA-R-1)
Tributary to Willamette River

Location:	Willamette River to Highway 43
Description:	Relatively wide free-flowing stream bordered by steep forested canyon walls. Upper segment is narrow and bordered by housing; lower segment is in Mary S. Young Park and flows into Willamette River after passing two trail culverts with significant drops (18" and 48"). Good off-channel / backwater habitat at confluence with river.
Fish bearing?	Yes (lower reach)
Fish barriers:	Seasonal/ tidal natural shelf at Willamette River
Channel type:	Moderately steep narrow valley channel
Bank/channel conditions:	Stable, natural condition
Notes:	Good river and east / west linkage; good potential fish habitat; pileated woodpecker habitat.
Recommendations:	Reconstruct trail crossings using bridges and restore free flowing channel connection to Willamette River. Manage invasive exotic species.

FES Field Notes 10/29/02:

In Mary S. Young State Park, steep, deep canyon with good riparian canopy and very large old growth Douglas fir (~7 ft dbh). Culvert under paved trail near bottom is angled 180E from the stream and it flows through a long culvert (obscured by blackberry). It then flows through a 3-foot concrete pipe that is broken with a 2-foot hanging drop. A sanitary sewer force main pipe (from Mapleton Pump Station) is across the stream. Manhole noted below in sand of river (low water day). Area has good potential for fish access and improved habitat by removing culverts and putting in boardwalks.

Upper Mary S. Young Creek (MA-R-2)
Tributary to Willamette River

Location:	Highway 43 to Miles Drive
Description:	Steep gradient stream through narrow, forested ravine fragmented by roads and housing; lower segment in open space.
Fish bearing?	No
Fish barriers:	Culvert – high gradient
Channel type:	Steep narrow valley channel.
Bank/channel conditions:	Stable, well vegetated
Notes:	Good pools, gravel / cobble substrate
Recommendations:	Remove ivy from trees; manage invasive species. Restore gaps in riparian corridor with native tree and shrub plantings.

BARLOW CREEK BASIN

Barlow Creek

Lower Barlow Creek (BA-R-1)
Tributary to Willamette River

Location:	Willamette River to Tomkins Street
Description:	Lower reach of Barlow Creek flows through a narrow, steep ravine and is piped below Willamette View Ct. and Failing St. before discharging to the Willamette River.

Fish bearing?	No; Information lacking
Fish barriers:	Culverts
Channel type:	Steep narrow valley channel
Bank/channel conditions:	Moderately disturbed, enters pipe
Notes:	Native flora holding on despite encroachment of blackberry and ivy.
Recommendations:	Manage invasives; restore vegetative connectivity and daylight channel where possible.

Upper Barlow Creek (BA-R-2)
Tributary to Willamette River

Location:	Barlow Street to Ibach Nature Park
Description:	Smaller stream originating near Sahallie Illahee Park and Ibach Nature Park; housing encroaching to edge and across stream in this reach.
Fish bearing?	No
Fish barriers:	Pipes
Channel type:	Moderately steep narrow valley channel.
Bank/channel conditions:	Some sluffing, downcutting
Notes:	Mixed tree ages, but generally younger stock
Recommendations:	Remove and manage invasive shrubs; add dense buffer; re-vegetate to reduce erosion and landslide hazard.

BOLTON CREEK BASIN

Bolton Creek

Bolton Creek (BO-R-1)
Tributary to Willamette River

Location:	Willamette River to Woodwinds Court
Description:	Steep gradient reach through a forested ravine with mature conifers, located partly in Burnside Park, flows into the Willamette River across from Goat Island.
Fish bearing?	No
Fish barriers:	Drops near Willamette River
Channel type:	Steep narrow valley channel
Bank/channel conditions:	Natural, stable, some erosion
Notes:	None
Recommendations:	Remove / manage invasives, limit debris dumping restore / re-vegetate eroded banks.

MADDAX CREEK BASIN

Maddax Creek

Maddax Creek (MX-R-1)
Tributary to Willamette River

Location:	Willamette River to Highway 43
Description:	Stream flows through steep narrow ravine with multiple smaller tributaries. Enters new city park before dropping steeply over the Willamette River bank across from Goat Island.
Fish bearing:	No

Fish barriers:	Drop to river
Channel type:	Moderately steep narrow valley channel
Bank/channel conditions:	Natural / semi-natural
Notes:	Mature trees provide good habitat, LWD recruitment potential.
Recommendations:	Restore and daylight channel in new park.

CASCADE SPRINGS POND BASIN

Cascade Springs Pond Creek

Cascade Springs Pond Creek (CS-R-1)
Tributary to Willamette River

Location:	Willamette River to Cascade Street
Description:	Perennial spring fed stream within a small forested ravine; wide central terrace contains braided channels and emergent wetlands.
Fish bearing?	No
Fish barriers:	River Drive culvert, 5-6-foot drop
Channel type:	Steep narrow valley channel
Bank/channel conditions:	Some downcutting, well vegetated
Notes:	Major ivy problem upstream, potential amphibian breeding.
Recommendations:	Remove trash; manage invasive species, particularly ivy and blackberry.

MCLEAN CREEK BASIN

McLean Creek

McLean Creek (MC-R-1)
Tributary to Willamette River

Location:	Willamette River to Highway 43 (under I-205 bridge)
Description:	Small free-flowing stream within forested ravine flows through McLean Park and cascades over rocky ledge before entering the Willamette River. Invasive species encroachment is high.
Fish bearing?	No
Fish barriers:	Steep drop to Willamette River
Channel type:	Moderately steep narrow valley channel
Bank/channel conditions:	Some grading below I-205
Notes:	Peregrine falcon aerie on I-205 bridge
Recommendations:	Remove ivy and blackberry, which have infested large areas of the corridor. Reestablish diverse native floral community.

CAMASSIA BASIN

Camassia Creek (No name on LWI / RCI maps)

Camassia Creek (CA-R-1)
Tributary to Willamette River

Location:	I-250 to Wilderness Park

Description:	Oak / madrone community with poison oak and licorice fern. Spring fed perennial stream flows through mostly forested corridor along edge of Wilderness Park and Camassia Natural Area, then is piped most of the way to Willamette river. Stony soils / basalt outcrops create unique habitats.
Fish bearing?	No
Fish barriers:	N/A (apparently long pipe to Willamette River)
Channel type:	Steep narrow valley channel
Bank/channel conditions:	Lower part deeply incised
Notes:	Braided channels, emergent wetland, unique habitats
Recommendations:	Manage invasive species and Douglas fir encroachment in oak woodland.

SUNSET CREEK BASIN

Sunset Creek (SU-R-1)
Tributary to Willamette River

Location:	Sunset Avenue to Charman Street
Description:	Short surface segment of mostly piped stream, flows through blackberry and invasive grass dominated residential back yards and along roadsides.
Fish bearing?	No
Fish barriers:	Not applicable
Channel type:	Moderately steep narrow valley channel
Bank/channel conditions:	Highly modified and degraded
Notes:	Isolated from habitat areas
Recommendations:	Restoration of stream channel and natural riparian edge to create a residential amenity.

LOWER WILLAMETTE RIVER (WI-R-1)

North City limits (Hog Island) to Cedar Island (RM 22.2 - 23.5)

Description:	Lowest reach of river narrowing to 300 feet and up to 100 feet in depth with several islands. River terraces stepping west into West Linn are developed with housing. North trending steams and forested ridges separate terraces.
Fish bearing?	Yes
Fish barriers:	None noted
Channel type:	Low gradient large floodplain channel
Bank/channel conditions:	Natural, some scour at streams
Notes:	Reach includes side channels, alcoves, rock ledges (some off channel habitat), potential amphibian breeding in ponds.
Recommendations:	Dense native re-vegetation; add conifers such as western red cedar to diversify habitat, add evergreen cover, plant native bottomland hardwoods such as cottonwood, ash, and willow to restore the riparian corridor and help shade out invasives; remove and manage invasive species.

CLACKAMAS RIVER CONFLUENCE (WI-R-2)
Cedar Island to Willamette Falls (RM 23.5 - 26.7)

Description:	A generally natural, well-vegetated riparian corridor borders this central Willamette reach, which, together with Goat Island, several forested parks (Mary S. Young, Burnside, and Maddax) and the Clackamas River confluence, creates a well-functioning habitat complex. Nesting peregrine falcons and one of the large great blue heron colonies along the Willamette River are found in this reach.
Fish bearing?	Yes (salmonids)
Fish barriers:	Willamette Falls (fish ladder exists)
Channel type:	Low gradient large floodplain channel
Bank/channel conditions:	Generally natural and stable
Notes:	Basalt ledges; large black cottonwood and conifers; diverse channel micro-topography with side channels, alcoves.
Recommendations:	Remove blackberry and other invasives, and re-vegetate with native bottomland hardwoods as cottonwood, ash, willow, and conifers (*e.g.*, cedar) for greater diversity.

UPPER WILLAMETTE RIVER WATERSHED

TANNER CREEK BASIN

Tanner Creek, Salamo Creek

Lower Tanner Creek (TA-R-1)
Tributary to Willamette River

Location:	Willamette River to Beacon Hill Court
Description:	Narrow, mostly wooded stream corridor with several streamside wetlands and two ponds; descends from Beacon Hill Ct. area to Imperial Dr. then in pipes and over rock ledges to Willamette River.
Fish bearing?	Yes
Fish barriers:	Culverts, steep drops
Channel type:	Moderately steep narrow valley channel
Bank/channel conditions:	High development, boulders
Notes:	Ponds provide stillwater habitat, potential amphibian breeding.
Recommendations:	Restore gaps in vegetated riparian corridor; plant native trees and shrubs to improve structural diversity, buffering values; manage invasives.

Upper Tanner Creek (TA-R-2)
Tributary to Willamette River

Location:	Beacon Hill Court to Rosemont Road
Description:	Moderate gradient headwater reach with several smaller tributaries, stream associated wetlands, and four ponds. New housing developments on south side of stream were under construction in May of 2002.
Fish bearing?	Yes
Fish barriers:	Culverts, modified channel
Channel type:	Moderate narrow valley channel

Bank/channel conditions:	Fair – rock lined in places.
Notes:	Braided channels, chorus frogs, limited conifers
Recommendations:	Restore native vegetation buffers along streams and wetlands; plant cedar and other conifers to diversify habitat. Remove obstacles for fish passage.

FES Field Notes 10/29/02:

Tanner Creek at the new Parker Road with new box arch culverts and bridges (fill with retaining walls made of concrete blocks). Farm Pond off Wildrose Drive, then manmade pond above Stonegate Lane Road and Beacon Hill Road stocked with 22+ large (~18") rainbow trout. Overflow system bypasses pond.

Salamo Creek (SA-R-1)
Tributary to Tanner Creek

Location:	Tanner Creek to Weatherhill Road (along Salamo)
Description:	Fragmented corridor with three on-line storm water facilities in developed areas; enters low gradient well-vegetated segment before confluence with mainstem Tanner Creek.
Fish bearing?	No
Fish barriers:	Culverts
Channel type:	Moderately steep narrow valley channel
Bank/channel conditions:	Fragmented braided areas.
Notes:	Regional stormwater facility at headwaters; potential septic system failures.
Recommendations:	Greater use of dense native emergents on stormwater facilities may improve water quality and habitat values. Repair facility septic systems. Large scale clearing of blackberry and native re-vegetation may be warranted, particularly on lower segment.

BERNERT CREEK BASIN

Bernert Creek

Bernert Creek (BE-R-1)
Tributary to Willamette River

Location:	Willamette River to Johnson Drive
Description:	Upper Bernert Creek follow I-205 embankment and is highly disturbed until it crosses Willamette Falls Drive, where it enters a forested ravine and meets wetland W1-03.
Fish bearing?	No (potential)
Fish barriers:	Culverts (drops)
Channel type:	Moderate gradient moderately confined channel
Bank/channel conditions:	Deeply incised sections.
Notes:	Lots of chorus frogs, potential fish access to lower reach from Willamette River.
Recommendations:	Restore vegetative buffer in upper section; add native trees, shrubs and herbaceous layer.

FES Field Notes 10/29/02:

At 5th Street 2-3-foot drop, 2-foot pool. Large cottonwood trees, potential fish habitat, connects to floodplain wetlands and drainage east of "Oregon City Mill" wastewater treatment pond.

WILLAMETTE LOWLANDS (WI-R-4)
Willamette Park to Bernert Creek

Description:	Broad Willamette floodplain area with a diverse mosaic of emergent, scrub-shrub, and forested wetlands linked by small east flowing drainages.
Fish bearing?	Potential
Fish barriers:	Culverts
Channel type:	Low gradient large floodplain channel
Bank/channel conditions:	Eroded where grazed
Notes:	Largest wetland complex in City
Recommendations:	Manage invasive exotics; restore vegetated buffers along riparian and wetland areas.

UPPER WILLAMETTE RIVER (WI-R-3)
Willamette Falls to Tualatin River (RM 26.7 - 28.5)

Description:	Upper, wide reach of river with broad floodplain below Tualatin River confluence; narrow, undifferentiated (straight) shoreline with links to diverse wetland complex on lowland (floodplain) terrace (WI-R-4).
Fish bearing?	Yes
Fish barriers:	Willamette Falls (fish ladder exists)
Channel type:	Low gradient large floodplain channel
Bank/channel conditions:	Bank fill and armoring in places
Notes:	Important confluence area with diverse wetland habitats
Recommendations:	Dense native re-vegetation; plant native bottomland hardwoods such as cottonwood, ash, and willow to restore the riparian corridor and help shade out invasives; remove and manage invasive species.

TUALATIN RIVER WATERSHED

FRITCHIE CREEK BASIN

North Fritchie Creek (FR-R-1)
Tributary to Tualatin River

Location:	Tualatin River to Wisteria Court
Description:	Diverse, cedar dominated mixed riparian forest with emergent wetlands at base of canyon slopes; includes headwall seeps and an old beaver pond.
Fish bearing:	Yes (ODFW)
Fish barriers:	Culverts limiting
Channel type:	Moderate gradient moderately confined channel
Bank/channel conditions:	Natural; lower end incised, eroded.
Notes:	Good mixed age cover both sides; regenerating cedars; old beaver dam, pond part of large wetland complex.
Recommendations:	Removal and management of invasive plant species, particularly reed canarygrass, blackberry and ivy; restore gaps in vegetated corridor along lower reach. Potential enhancement opportunities include replacement of the culverts under I-205 with large arch culverts or bridges that could restore free

passage of fish and wildlife between Fritchie Creek and Tualatin River riparian habitats.

South Fritchie Creek (FR-R-2)
Johnson Creek or Summerlinn Creek (as named by the surface water management plan)
Tributary to Fritchie Creek

Location:	Fritchie mainstem to Crestview Drive
Description:	Forested, generally narrow and fragmented reach with park near headwaters. Includes large (>40 inch diameter) cedars, firs and maples, and the oldest Pacific madrone trees observed in the City, potentially in region. (Fritchie mainstem to Crestview Drive.)
Fish bearing:	No (potential)
Fish barriers:	Multiple culverts
Channel type:	Moderately steep narrow valley channel
Bank/channel conditions:	Moderate to high alteration; limited erosion.
Notes:	Mature trees provide good habitat, LWD recruitment potential
Recommendations:	Restore and / or widen forested corridor where opportunities exist, add dense native shrub buffer along roads and edges where expanding corridor not possible; remove invasives.

FES Field Notes 10/29/02:

Lots of private road crossings and culverts along Johnson Road. Not much habitat, hard to connect to anything higher in the watershed due to I-205 crossing and only 1-2 miles of upstream channel available.

LOWER TUALATIN RIVER (TU-R-1)
Willamette River to Borland Bridge

Description:	Swift flowing lowest reach of Tualatin River before confluence with Willamette River; well vegetated corridor with large forested hillside to south and residential areas of West Linn to north.
Fish bearing?	Yes (winter steelhead, Coho salmon)
Fish barriers:	None
Channel type:	Low gradient medium floodplain channel
Bank/channel conditions:	Natural / semi-natural
Notes:	Remnant slough (oxbow); seasonal waterfall
Recommendations:	Plant native shrubs and trees to diversify mid-canopy / understory.

UPPER TUALATIN RIVER (TU-R-2)
Borland Bridge to City limits (Fritchie Creek)

Description:	Broad Tualatin Valley floodplain with associated wetlands narrows into forested canyon near Borland Bridge. A steep forested ridge separates the floodplain terrace (open space) from the upland terrace (housing).
Fish bearing?	Yes
Fish barriers:	None
Channel type:	Low gradient medium floodplain channel
Bank / channel conditions:	Natural / semi-natural (some fill)

Notes:	Fritchie Creek confluence is at upstream end of reach
Recommendations:	Restore gaps in vegetated shoreline; manage invasive species, particularly grasses and emergents, and Himalayan blackberry.