STORM DRAINAGE SYSTEM

MASTER PLAN

May 8, 2002

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CITY OF MT. ANGEL
STORM DRAINAGE SYSTEM MASTER PLAN

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FOREWORD

USING THIS REPORT

Because this report will be used by many people whose needs for detailed information will differ widely, an Executive Summary has been included at the beginning of this report. This executive summary contains a summary and overview which briefly describes the content and main conclusions of the report. Thus, readers may gain a good general understanding of the direction of the report and its contents by reading the Executive Summary. If a reader wishes to explore the subject in greater detail, the appropriate section in the text can be consulted. Each section has also been generally organized so as to move from the general to the specific.

CITY OF MT. ANGEL
Storm Drainage System Master Plan

Executive Summary

EXECUTIVE SUMMARY

INTRODUCTION

This Storm Drainage System Master Plan assesses the City's existing storm drainage system and provides recommendations for drainage within the City of Mt. Angel. Without the benefit of a storm drainage master plan, storm drainage improvements are often constructed as needed without analyzing overall system needs and impacts. Although this approach alleviates isolated problems, there is no way of making well informed decisions regarding improvements to the system, or assessing the potential impact of future development.

The City's current development standards require findings that adequate capacity is available in the utility systems prior to development occurring. Without a current storm drainage system master plan that identifies area-wide improvements required with a schedule guiding their construction, implementation of these policies is difficult. Without a community wide understanding of how the storm drainage system works and how development within the community impacts its performance, it is difficult at best to determine what improvements to the storm drainage system are required by new development.

PROJECT OBJECTIVES

The primary purpose of the master plan is to provide the City with specific engineering recommendations for the management of storm drainage throughout the study area. It is intended that the information contained herein assist the City in the planning and implementation of capital improvements to the storm drainage system, as well as ongoing system maintenance.

ELEMENTS OF THE MASTER PLAN

■ ■ Section 2, Study Area and Planning Considerations

Mt. Angel is located in the Willamette Valley 15 miles northeast of Salem at the base of the Cascade foothills. The City consists of approximately 625 acres inside the City limits, with an additional 245 acres outside the City limits but within the UGB. This study also evaluates areas upstream and downstream of the City to ensure the influences of these areas are properly addressed in the analysis.

The City has three land use zones: residential, commercial, and industrial. The land within the City limits has not fully developed to the degree allowed by the zoning standards. Land within the UGBand outside the City Limits is generally undeveloped, or developed at levels far below what may be allowed upon annexation. The study evaluates the storm drainage system both according to the current state of development, and assuming the full 870 acres is developed to the full extent allowed by the current zoning ordinances.

■ ■ Section 3, Description of the Existing System

The City is divided into two main drainage basins designated in the report as the North Basin and the South Basin, plus three additional minor basins on the perimeter of the City. The North Basin consists of approximately 384 acres generally north of Church Street. The South Basin, predominantly south of Church Street consists of approximately 316 acres. The minor basins, designated by the geographic location as Northwest, Southwest, and East, consist of 117 acres, 45 acres, and 39 acres, respectively.

The two major drainage basins are served by storm drain trunk line systems running from east to west, with the discharges near the west City Limits. The North Basin system is a relatively complex network of main routes and overflow paths that ultimately discharge at Marquam Street. The South Basin is primarily served by a major trunk line discharging at West Church Street, and working its way east until the Garfield street area.

When all of the various elements of the storm drainage system are totaled, the City has over 58,000 feet of pipe ranging in size from 6-inches in diameter up to 48-inches in diameter. There are also roughly 360 catch basins and 70 manholes, as well as approximately 2.5 miles of ditches.

■ ■ Section 4, Hydrologic/Hydraulic Analysis

The primary method for calculating the predicted stormwater run-off was using the Haested Method PondPack Santa Barbara Urban Hydrograph (SBUH) computer modeling program. To use this program, the two drainage basins were divided into sub-basins generally defined by a region's downstream intersection with the basin's major storm drain trunk line. The North Basin was divided into 14 sub-basins while the south was broken up into 9 sub-basins.

Calculations were performed for existing and future development conditions using 25-year design storms, which is the storm event specified for the analysis of trunk lines 18-inches in size or larger. Once the run-off calculations were completed, the predicted flows were used to assess the adequacy of the major trunk lines. Ideally, the trunk lines should have the capacity to carry the 25-year storm without surcharging.

■ ■ Section 5, Storm System Evaluation and Recommendations

The evaluation of the North Basin indicates that large portions of the major trunk line system are adequate for both existing and projected future flows. The most prominent problem area is from John Street east over to Garfield Street and up to Marquam Street. This area contains a series of 36-inch and 30-inch pipes to Garfield Street, and an 18-inch pipe in Marquam Street that are undersized for the projected flows. The recommended solution is to construct a new 36-inch pipe in John Street up to Marquam Street, then over to the west side of the Middle School.

Other problem areas in the North Basin include the culverts crossing Marquam Street at the west City Limits, the 48-inch trunk line heading southeast into the City from the Marquam Street culverts, and a 27-inch pipe from Marquam Street just east of Pershing Street running northeast

to the railroad tracks. An additional 48-inch culvert across Marquam Street would provide the necessary capacity in that location. The capacity of the 48-inch trunk line must have its capacity supplemented. Currently there is a 24-inch pipe parallel to the 48-inch that serves little purpose, and could be put to use with minimal cost or effort. This would add some capacity, but not enough for all of the projected future flows. The long term solution in this location is to replace the 24-inch with a 36-inch pipe. The 27-inch from Marquam Street to the railroad needs to be replaced with a 36-inch pipe, but such replacement may wait until development of this area.

The majority of the major trunk line for the South Basin is marginal at best, and in large sections it is substantially undersized. The proposed solution to this serious problem is to construct a new 48-inch line in Academy Street, and then south along Highway 214 that will carry flows from sub-basins S7, S8, and S9. If this line was constructed, the existing trunk line would have sufficient capacity to carry both existing and projected future flows.

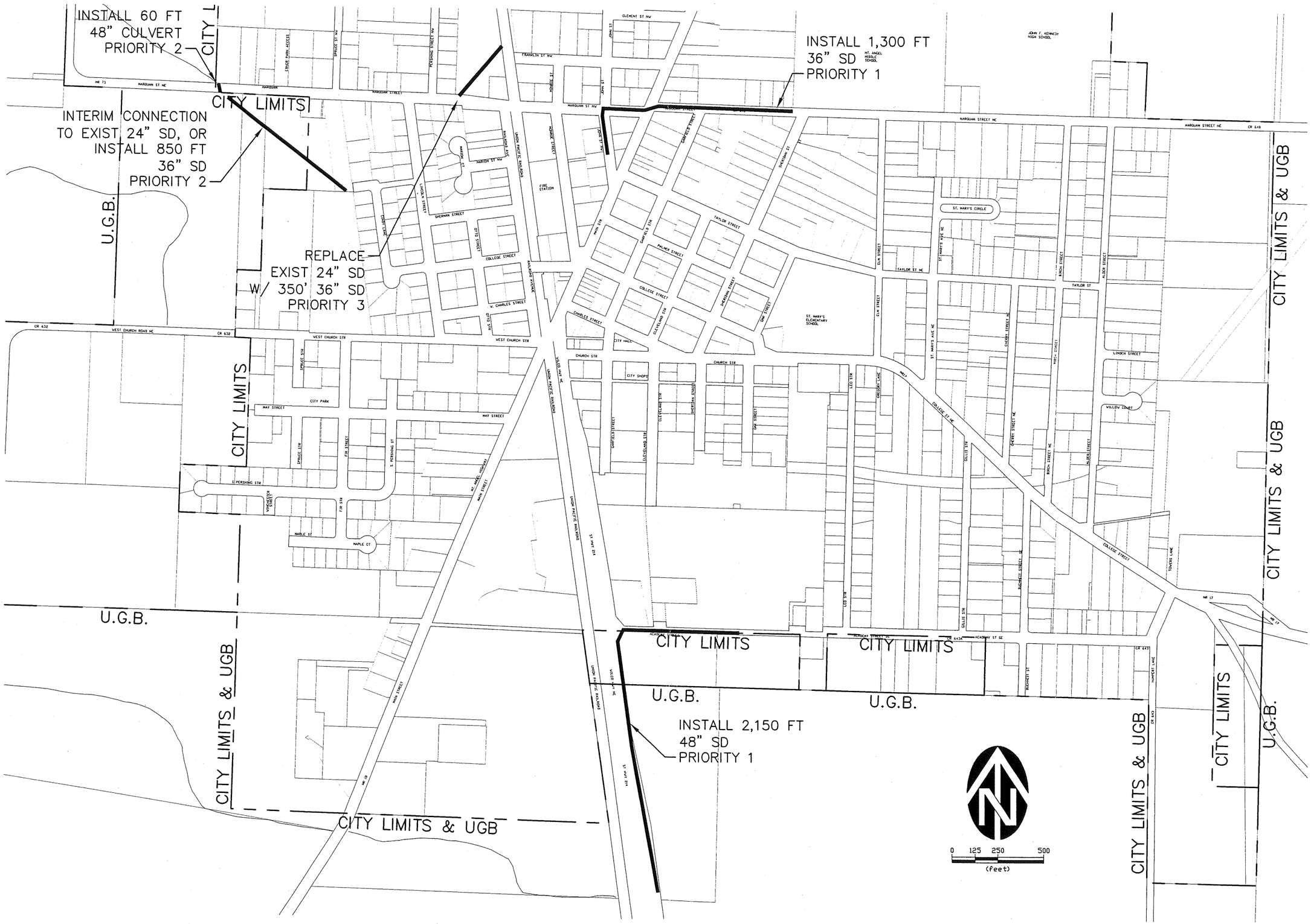
The recommended improvements, and their associated costs are summarized in **Figure 5-13** and **Table 5-13**, which are included on the following pages for the convenience of the reader.

This section also provides a discussion on stormwater detention explaining the purpose of detention, the most important benefits, and pointing out certain costs and disadvantages. In general detention is most beneficial to the storm drainage system immediately downstream of a development site. The benefit to the major trunk lines, while it exists, can be less dramatic. The major drawbacks to detention relate to the cost to development, in either money or lost developable ground, or both. Weighing the benefits and drawbacks of detention within the context of Mt. Angel's specific situation, we recommend that the City continue to support its current stormwater detention standards.

Finally, we have identified several local problem areas where the existing drainage system does not function as desired. The report lists these areas and makes suggestions as to possible remedies that the City may wish to pursue.

■ ■ Section 6, <u>Design Standards and Management Practices</u>

This section provides a discussion of the standards and procedures the City has adopted to promote an efficient, effective storm drainage system. Included in this section are general discussions of Storm Drainage System Design Standards, Stormwater Quality Standards, Storm Drainage System Construction Standards, and Management Practices. In addition, we have provided information concerning legal and liability issues, as well as system funding issues.



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CITY OF MT. ANGEL, OREGON

MT. ANGEL STORM DRAIN MASTER PLAN

RECOMMENDED
CAPITAL IMPROVEMENT PLAN
(CIP) PROJECTS

FIGURE 5-13

SHEET
1 OF 1

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TABLE 5-13

Capital Improvement Project (CIP) Estimated Costs*

PROJECT	Priority	Pipe Size (in)	Paved or Unpaved	Length (ft)	Cost/ft ($)	Manholes	Cost/Ea ($)	Inlets	Cost/Ea ($)	Construction Cost ($)	Contingency (10%)	Engineering (16%)	Legal & Admin (10%)	Project Total ($)
NORTH BASIN														
Marquam St Culvert	2	48	Paved	60	$250					$15,000	$1,500	$2,400	$1,500	$20,400
36-inch Pipe by 48-inch pipe S. of Marquam St	2	36	Unpaved	850	$130	2	$10,000	2	$1,000	$132,500	$13,250	$21,200	$13,250	$180,200
36-inch pipe, Marquam St to RR	3	36	Unpaved	350	$130	1	$7,500	2	$1,000	$55,000	$5,500	$8,800	$5,500	$74,800
36-inch pipe, John St to Middle School	1	36	Paved	1300	$160	6	$10,000	12	$1,000	$280,000	$28,000	$44,800	$28,000	$380,800
SOUTH BASIN														
48-inch pipe, Academy St and Wilco Highway	1	48	Unpaved	2100	$180	6	$7,500	2	$1,000	$425,000	$42,500	$68,000	$42,500	$578,000

*Note: These estimates are planning level cost estimates and not based on actual designs. They should be considered as preliminary and subject to change.

CITY OF MT. ANGEL
Storm Drainage System Master Plan

Section 1

INTRODUCTION

SECTION 1
INTRODUCTION

1.1 Background

Mt. Angel is located in north central Marion County, approximately 15 miles northeast of Salem, in the heart of the Willamette Valley. Incorporated in 1893, the City of Mt. Angel has grown to a population of approximately 3,400 in 2001, according to the Population Research Center at Portland State University. The Urban Growth Boundary (UGB) encompasses 870 acres, of which approximately 625 acres are within the City Limits. Mt. Angel has developed a stable economy with strong agricultural and diversified small commercial and industrial sectors.

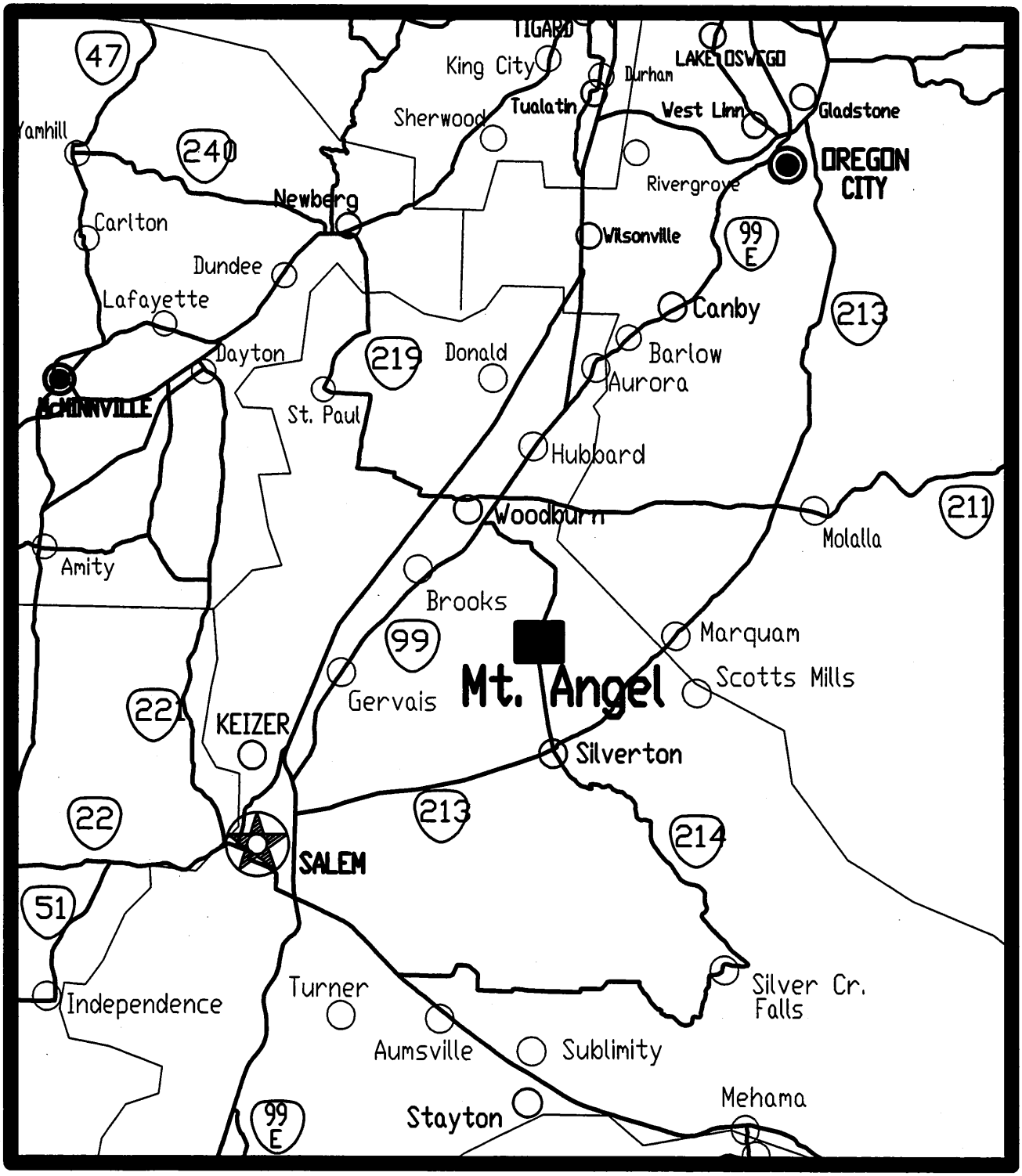
The City is currently divided into two main drainage basins, generally dividing north and south of Church Street. Each basin is served by a primary storm drain trunk line that collects the drainage from the various sub-basins and conveys it to the west out of the City. Overall, much of the City's storm drainage system appears to be fairly well designed and suitable to handle anticipated demands. However, there are a number of areas that will require attention to correct shortcomings.

The North Basin is served by a 48-inch diameter trunk line and a series of overflow routes that appear generally adequate for both current and future flows. While generally in good shape, there are a number of inadequacies in need of correction. The trunk line for the South Basin is currently inadequate for current flows, and will become even more overtaxed as development occurs. However, a relatively simple system modification appears to provide the opportunity to correct most of the major problems with the South Basin trunk line. Beyond the trunk lines, there are also a few specific drainage system problems that have been identified and will be addressed by this report.

Building on a detailed analysis of the City's basins and sub-basins, this report provides a comprehensive look at the City's storm drainage system to establish a baseline for future upgrades to the main drainage systems as necessary, reviews requirements for storm drainage detention, and references standards for improvements to local storm drainage facilities.

1.2 Authorization

In September of 2000, the City authorized Westech Engineering to prepare a Storm Drainage System Master Plan for the City. The report will be the City's guide to establish a program for upgrading existing storm drainage facilities, establishing storm drainage system design and construction standards, establishing stormwater run-off detention requirements, and implementing storm drainage management procedures. Originally scheduled for completion in May of 2001, the City and Westech Engineering agreed to delay delivery for one year due to the drought during the winter of 2000-2001.



VICINITY MAP

FIGURE 1–1

1.3 Project Objectives

The purpose of this study is to evaluate the portion of City's storm drainage system with respect to its existing and future needs; identify improvements and associated costs necessary to meet those needs; and provide the City with a design guide for future growth of the City's storm drainage system in this area. It is intended that the information contained herein assist the City in the planning and implementation of capital improvements to the storm drainage system, as well as ongoing system maintenance.

This evaluation and master plan accomplishes the following specific objectives.

- Identify and delineate the boundaries of the major drainage basins within the Planning Area.
- Map the applicable portion of the existing storm drainage system based on field data collection and as-built drawings.
- Identify current and future storm drain system deficiencies within the applicable basins, particularly in the following areas:
    - Localized flooding, flow routing capacity
    - System reliability
    - Maintenance considerations
- Analyze the drainage systems under fully developed (buildout) conditions to determine the most cost effective approach to drainage management within the study area.
- Provide an evaluation of the options for correcting these deficiencies with preliminary construction cost estimates for recommended alternatives.
- Provide specific recommendations to the community and City Council for action.

This report does not include a wetland inventory or delineations, on-site environmental investigations or geotechnical investigations.

1.4 Prior Studies and Work

The most recent studies, reports and documents utilized in the preparation of this master plan are as follows:

- Master Drainage Plan, for the City of Mt. Angel, Oregon by Westech Engineering, July 1982.
- Flood Insurance Study, Marion County, Oregon, Unincorporated Areas, by Federal Emergency Management Agency, January 19, 2000.

- Soil Survey of Marion County Area, Oregon, by USDA Soil Conservation Service, September 1972.

- Public Works Design Standards for the City of Mt. Angel, Oregon by Westech Engineering, September 1996.

CITY OF MT. ANGEL
Storm Drainage System Master Plan

Section 2

Study Area and Planning Considerations

SECTION 2
STUDY AREA AND PLANNING CONSIDERATIONS

2.1 Study Area

The City of Mt. Angel is located in Marion County approximately 15 miles northeast of Salem, 4 miles north of Silverton, and 8 miles south of Woodburn. The primary study area is coincident with the Urban Growth Boundary (UGB) established by the City's Comprehensive Plan. However, since the storm drainage system within the UGB is influenced by run-off from upstream of the City, as well as the performance of the downstream drainage system, these areas were also investigated as part of this study.

The City is bisected north to south by Highway 214 and the Old Mt. Angel Highway. These two roads intersect at the City center (Church Street), and provide the major road transportation route to Mt. Angel. Highway 214 is variously designated as the Wilco Highway, Mt. Angel Hillsboro Highway, and the Mt. Angel Silverton Highway. The Union Pacific Railroad Co. also has a rail line passing through the City north to south.

As previously noted in the introduction, the Urban Growth Boundary (UGB) currently encompasses approximately 870 acres, of which approximately 625 acres are within the City Limits. Eventually the entire area will be part of the City and will be served by the City's utility systems.

This report is based on the assumption that there will be no significant changes to the Urban Growth Boundary during the study period. The improvements recommended in this plan are based on development of land within the UGB in its present location, as well as the existing land use zoning for these areas. It is assumed that no significant development will occur within the study area that will require major changes to the existing zoning. Changes in any of these assumptions could change the recommendations contained in the master plan. Should significant changes in any of the above occur, the master plan should be updated accordingly.

2.2 Climate and Rainfall Patterns

The study area is located east of the area in the north central Marion County commonly referred to as Howell Prairie, and is close to the foothills of the Cascade mountain range.

Since there is no National Weather Service recording station in Mt. Angel, rainfall data from Silverton was examined. As noted above, Silverton is just four miles south of Mt. Angel. Their common location at the eastern edge of the Willamette Valley, at the base of the Cascade foothills provides a basis for assuming similar weather patterns.

The weather is characterized by cool wet winters and warm dry summers. Winters are typically mild, with very low temperatures being uncommon. Summers are generally mild with little precipitation. Average high temperatures range from the mid 40's to the low 50's in the winter months and are in the 70's in the summer. Average low temperatures run in the mid-30's to low 40's in the winter, and are in the low 50's in the summer.

The study area receives an average of approximately 46 inches of precipitation annually, with the majority of the rainfall occurring during the winter months. Oregon Climate Service records for Silverton start in 1962. Since then, the wettest year was 1996 when approximately 77 inches of rainfall was measured. The second wettest year, based on a complete year of records was 1968, with approximately 59 inches of rainfall. Approximately 2/3 of the annual precipitation occurs between November 1 and April 30. Winters are characterized as mild, with very low temperatures being uncommon. Summers are generally mild with little precipitation. July is typically the driest month with an average rainfall for the month of just under one inch.

Table 2-1 summarizes the 24-hour rainfall intensity data for the Mt. Angel area.

TABLE 2-1
Storm Event, 24 Hour Rainfall Intensities

Storm Event	24 hour Precipitation (inch)
2-year 24-hour	2.5
5-year 24-hour	3.0
10-year 24-hour	3.5
50-year 24-hour	4.4
100-year 24-hour	4.5

[1] – From 1973 NOAA Atlas 2, Volume X (Oregon).

The rainfall-intensity-duration curve for use in the City of Mt. Angel for sizing storm drain piping under the rational method is the ODOT Zone 8 curve (see Public Works Design Standards).

2.3 Topography

Mt. Angel is located east of the Pudding River, approximately 40 miles upstream of the point where the Pudding River enters the Willamette River. The City center is located on the first major bench east of the Pudding River. The natural surface drainage across the study area flows to the west into the Pudding River. The most prominent topographic feature is Mt. Angel, which is located at the southeast corner of the city, and rises to a height of 485 feet above sea level.

The topography within the City Limits and the UGB is generally gently sloping and undulating. The topography within the study area ranges from relatively flat within the majority of town to somewhat steeper slopes near the base of Mt. Angel in the southeast corner of town. The elevation within the study area ranges from approximately 150 feet on the west edge of the City to about 250 feet near the southeast corner of town. The majority of the land within the UGB is at or below an elevation of 200 feet, with the City center having an elevation of approximately 170 feet.

2.4 Soils and Geology

A variety of soils are found in Mt. Angel. Although a detailed analysis of the soils and geology is outside the scope of this report, a review of information from existing soil surveys was performed. In 1972, the Soil Conservation Service published a detailed report entitled, "Soil Survey of Marion County, Oregon," which documents and maps the different soil types within the County. Soil information from the Soil Survey is provided in **Appendix A**.

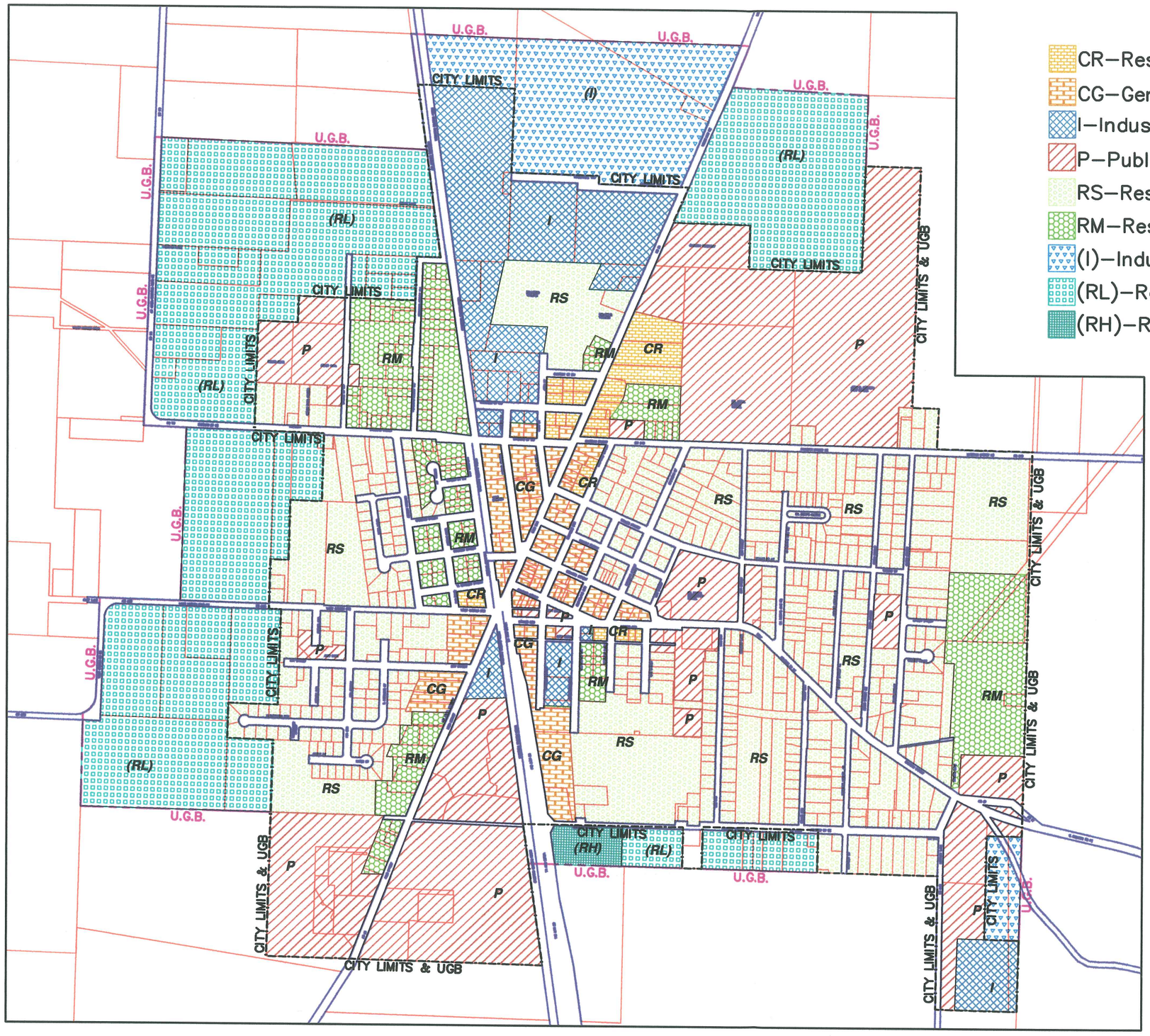
Almost all soil within the City limits belong to the Amity, Concord, Dayton, and Woodburn series with Amity the most prevalent. In general, the soils experience high water tables during the winter months and have moderate to low permeabilities. These soils are typically resistant to infiltration, and thus result in a higher natural run-off than would be normally found in sandy or gravelly soils. The soil descriptions indicate that run-off is slow, but that is due to the flat terrain where these soils are found. One positive consequence of having these types of soils is that there is a smaller increase in run-off when a property develops than would occur with more pervious soils.

The importance of these classifications to this report is to emphasize that the soil infiltration capacity within the developable portions of the study area is limited at best, particularly during the late winter months after the ground has become saturated.

2.5 Land Use and Community Planning

Land within the City is divided into three general zones based on the type of use allowed (ie. Residential, Commercial, and Industrial). The Zoning Map (**Figure 2-1**) shows the location of the UGB, City limits and land use zoning designations within the City. **Table 2-2** summarizes the approximate areas contained under each zoning designation.

For the purposes of this study land use was examined under both its current state of development and assuming all land would develop to the full use of the designated zone, both for land within the City Limits and land inside the UGB. Land outside the UGB was assumed to remain in agricultural use.



CR—Residential Commercial
CG—General Commercial
I—Industrial
P—Public
RS—Residential Single
RM—Residential Multiple
(I)—Industrial, County
(RL)—Residential, Low Density, County
(RH)—Residential, High Density, County

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(Feet)

NO.	DATE	DESCRIPTION REVISIONS	BY

DSN. RE
DRN. RE
CKD. RE
DATE: JAN 02

MAP UPDATED: 1-25-02

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CITY OF MT ANGEL, OREGON

ZONE MAP

SHEET 1 OF 1

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TABLE 2-2 Approximate Areas by Land Use Category			
Category	Total Area (acre)		
	Within City Limits	Between City Limits & UGB	Total Within City Limits and UGB
RS – Residential Single Family	222	N/A	222
RM – Residential Multi-Family	58	N/A	58
CR – Commercial Residential	12	N/A	12
CG – Commercial General	26	N/A	26
I – Industrial	53	N/A	53
P – Public	160	N/A	161
Right-of-Way	94	11	105
UGB(RL) – Residential, Low Density	N/A	185	185
UGB (RH) – Residential, High Density	N/A	4	4
UGB (I) - Industrial	N/A	45	45
TOTAL	**625**	**245**	**870**

2.6 FEMA Flood Insurance Status

In 1968, the U.S. Congress passed the Flood Insurance Act which established a federal program enabling property owners to buy flood insurance at a reasonable cost (FEMA, 1980). In return, communities carry out local floodplain management measures to protect lives and new construction from future flooding. The program is administered by the Federal Insurance Administration within the Federal Emergency Management Agency (FEMA).

Continued encroachments on floodplains decrease the natural flood-control capacity of these land areas, creates the need for expensive manmade flood-control measures and disaster-relief activities, and endangers both lives and property. Projects obtaining federal funding must demonstrate compliance with federal floodplain management regulations, and avoid to the extent possible:

- The long and short-term adverse impacts associated with the occupancy and modification of floodplains, and

- Direct or indirect support of floodplain development wherever there is a practicable alternative.

The relevant floodplain for most proposed projects is an area that has a 1-percent chance of a flood occurrence in a given year. The flood of this interval is referred to as the 100-year flood or the base flood. The floodplain management guidelines further require Federal agencies to apply the 0.2 percent or 500-year flood occurrence standard to the location of “critical facilities.” Facilities considered “critical facilities” are those whose loss would disrupt utility service to large areas for a considerable period of time or would disrupt utility service to critical facilities such as hospitals. Critical facilities include water treatment plants, wastewater treatment facilities, large pump stations, and centralized operations or communication facilities.

Mt. Angel is located in northern Willamette Valley on the first bench west of the Pudding River. The elevation within the study area is generally above 150 feet (above sea level). The Pudding River is located west of town, and flows from south to north west. The Federal Emergency Management Agency (FEMA) has established 100-year floodplain designation and insurance ratings areas along the Pudding River and its tributaries. While sometimes referred to as the "100 year flood", it is more accurate to consider it the flood having a 1 percent chance of occurrence in any year, or a 10 percent chance of occurrence during any 10 year period. The 500 year flood is a flood having a 0.2 percent chance of occurrence in any given year.

Both the City of Mt. Angel and Marion County presently participate in the regular phase of the Flood Insurance Program (date of entry into the Regular Program for Mt. Angel was June 30, 1976, for Marion County it was August 15, 1979).

According to the FEMA “National Flood Insurance Program Community Status Book,” the City of Mt. Angel is listed as having no current flood map published for areas within the City Limits, but is still participating in the National Flood Insurance Program.

Flood profiles and maps for those portions of the Pudding River adjacent to the study area are included in the Flood Insurance Study prepared for Marion County Unincorporated Areas as follows.

- FIRM panel 250 of 1150 (map 41047C0250 G) dated 1/19/00

The entire study area and all of the proposed improvements are above the 100 year and the 500 year flood plain of the Pudding River. The current FIRM panel indicates that no flood elevations have been determined for the Pudding River west of Mt. Angel. The nearest portion of the floodplain to the City is directly to the west, approximately one mile from the western city limits.

There is an area within the City Limits that is subject to local shallow flooding, and that used to be classified as a special flood hazard area. This area includes the low area at the south end of Cleveland Street. However, flooding in this area is due to backup of inadequate drainage facilities rather than flooding from nearby creeks or streams, and is therefore not shown on current FEMA flood maps.

CITY OF MT. ANGEL
Storm Drainage System Master Plan

Section 3

Description of Existing System

SECTION 3
DESCRIPTION OF EXISTING SYSTEM

3.1 General

The City's existing storm drainage system collects stormwater from open areas, streets, residences, businesses, industries, and public facilities and conveys the runoff to drainage channels outside the City that discharge to the Pudding River. Flow through the storm drainage collection system is by gravity. There are no public storm drainage pump stations within the City.

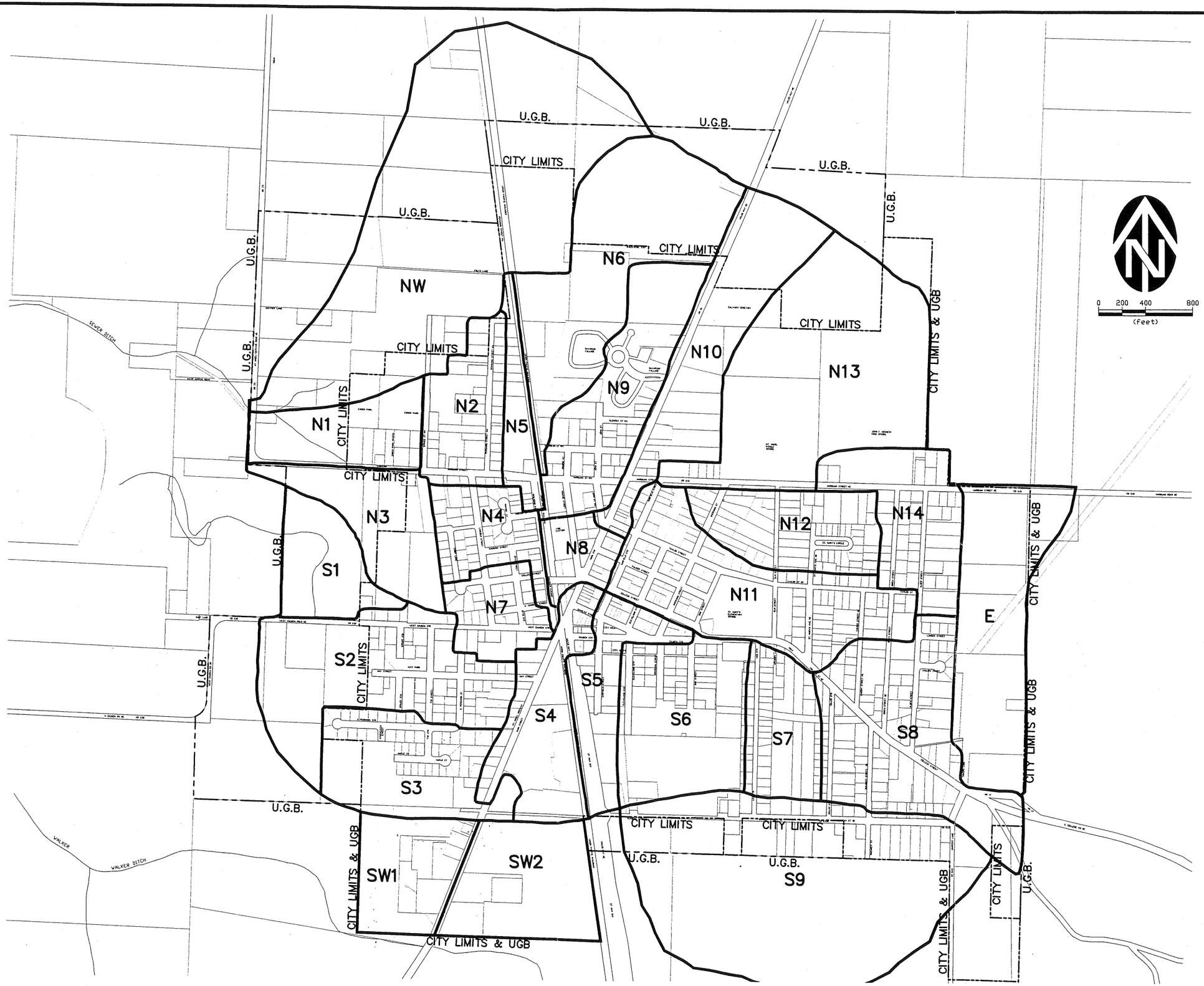
This section provides an overview of the existing storm drainage system within the study area and summarizes known or reported problems.

3.2 Stormwater Drainage Basins

As shown on **Figure 3-1**, the study area is divided into a number of drainage basins. The two largest basins, North and South, cover the majority of the City. Several smaller basins exist on the outside edges of the City covering areas that are currently only lightly developed. The basin boundaries were determined based on the topography, layout of the storm drainage system, and field investigation of actual drainage patterns. **Table 3-1** lists the approximate areas within each of the major drainage basins shown. Each of these major drainage basins was then divided into sub-basins as appropriate to more accurately define their hydrologic characteristics.

Table 3-1
Major Drainage Basin Areas

Basin Name	General Drainage Basin Location	Area (Acres)
NW	Area north of Marquam Street that drains directly to Mt. Angel-Gervais Road west of town	117
N	Area north of Church Street draining to Marquam Street at the west end of town	384
S	Area south of Church Street draining to Church Street	316
SW	Area south of Academy Street alignment draining to Walker Ditch	45
E	Area east of Humpert Lane (including Mt. Angel Towers) draining to Marquam Street at the east end of town	39
	Total	901



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CKD. RCE
DATE:MAR '02

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CITY OF MT. ANGEL, OREGON

MT. ANGEL STORM DRAIN MASTER PLAN

STORM DRAINAGE SUB-BASIN MAP

FIGURE 3-1

SHEET 1 OF 1

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Within the study area, several jurisdictions have responsibility for design and maintenance of the storm drainage system. In addition to the City, who is responsible for the majority of the system, the Oregon Department of Transportation (ODOT) is has jurisdiction over facilities in the right-of-ways along Main Street (Hwy 214), while Marion County technically has jurisdictional oversight over facilities within County right-of-ways. Marion County typically defers review to the City for storm drainage facilities in County right-of-ways within City Limits. Union Pacific Railroad has jurisdiction oversight for the portion of storm lines crossing the railroad right-of-way.

3.3 Existing System

The **Storm Drainage System Map** (**Figure 3-2**) shows the location and size of the existing known drainage system elements. A full scale copy of this map is included in **Appendix B**.

The existing storm drainage system is a combination of open channels, storm pipes and culverts in the well developed areas of the City, and roadside ditches, cross country ditches and perennial streams, and cross culverts in the less developed areas. The total estimated length of pipe in the drainage system is approximately 58,000 feet (±11 miles) with ±360 catch basins and ±70 storm drain manholes. The remainder of the storm drainage system consists of small perennial streams and constructed open channels, including roadside ditches. A detailed inventory of these channels and ditches was not performed, but the total appears to be in excess of 2.5 miles (excluding highway and railroad ditches).

As previously noted, the study area is crossed by three major transportation corridors, Highway 214, the Old Mt. Angel Highway and the Union Pacific Railroad. These corridors are the major obstacles that have modified the natural path of runoff flowing out of drainage basins upstream of these facilities, and the placement and sizing of these crossings effects the amount of runoff to downstream drainage areas. The major storm lines crossing the Highway and railroad within or adjacent to the City are as follows, listed from north to south.

Highway 214 (North Main Street/Wilco Highway)

- 30" concrete, Taylor Street
- 30” concrete, between Palmer & College Street
- 3’ x 5’ box culvert, south end Garfield Street
- 6’ x 9’ CMP culvert, south of City Limits

Railroad

- 18” CMP, north end of Mt. Angel Beverage property
- 3’ x 4’ box culvert, north of west end of Franklin Street
- 42”, Marion Street
- 3’ x 5’ box culvert, Sherman Street
- Twin 30” concrete, south end Garfield Street
- 6’ x 6’ box culvert, south of City Limits

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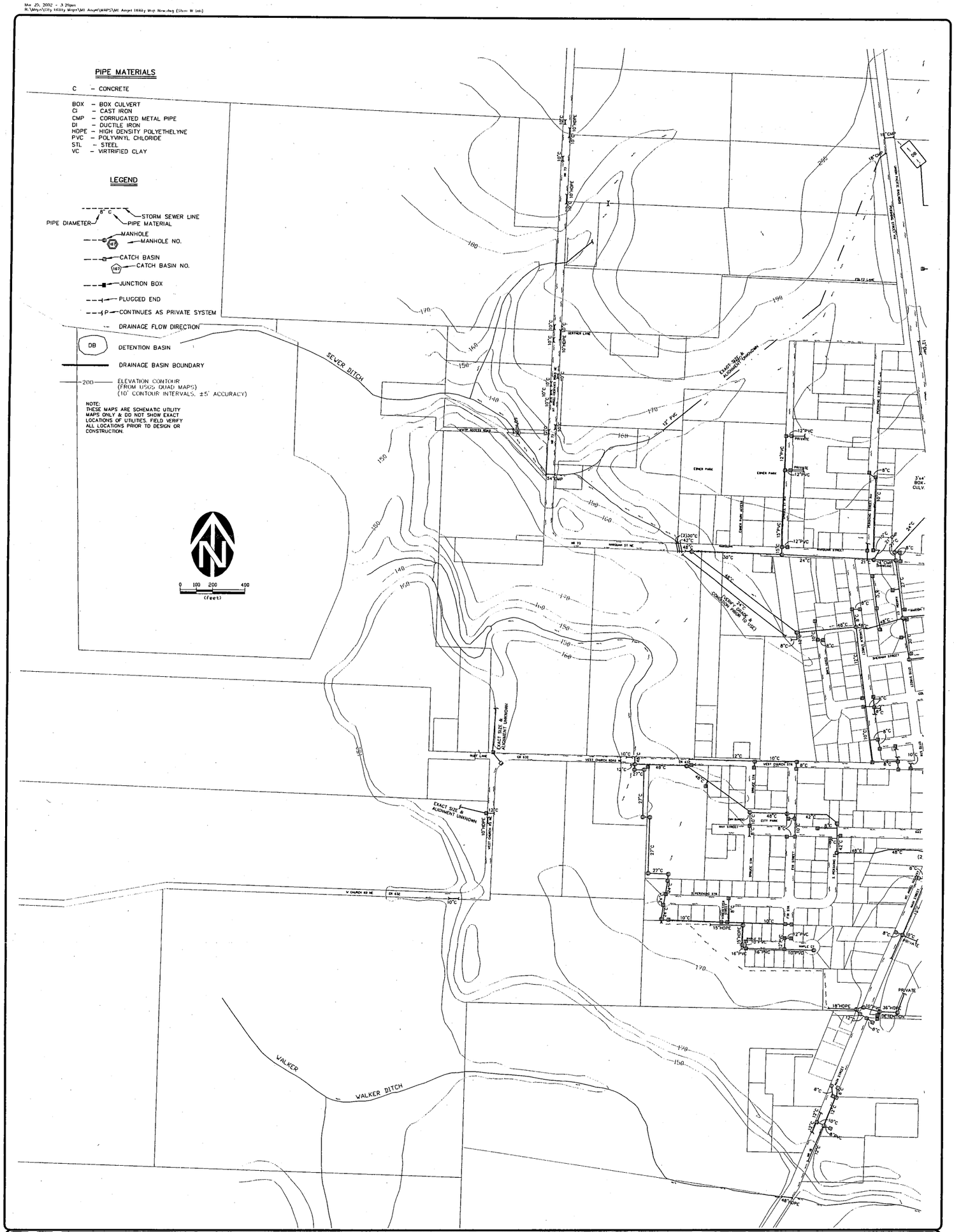

CITY OF MT. ANGEL, OREGON

WEST STORM DRAINAGE SYSTEM MAP

FIGURE 3-2a

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DATE: JAN 2001

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CITY OF MT. ANGEL, OREGON

EAST STORM DRAINAGE SYSTEM MAP

FIGURE 3-2b

SHEET 2 OF 2

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CKD. DM
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Old Mt. Angel Highway (South Main Street)

- Twin 30" concrete culverts, south of May Street
- 10” PVC and 12” Concrete, Academy Street alignment
- 48” HDPE culvert, south of City Limits

Table 3-2 contains a summary of the estimated quantities of piping by size and material type in the storm system by material type and diameter.

Table 3-2
Storm Drainage System, Estimated Piping Quantities

	Total Estimated Pipe Quantities (feet)					
Pipe Size	Concrete	PVC	HDPE	CMP	CI/DI	Totals
6”	970	120	100		170	1,360
8”	15,640	80	120	330	210	16,380
10"	4,850	1,530	70		20	6,470
12"	13,310	230	390	170	60	14,160
15"	3,260	890	320			4,470
18"	2,180		180	50		2,410
21”	1,130			60		1,190
24"	2,550			140		2,690
27”	1,230			200		1,430
30"	2,540					2,540
36"	300			260		560
42”	1,350					1,350
48”	3,160		70			3,230
Totals	52,470	2,850	1,250	1,210	460	58,240

Number of Catch Basins = ±360 Number of Manholes = ±70

PVC = Poly Vinyl Chloride HDPE = High Density Polyethylene CMP = Corrugated Metal Pipe
CI = Cast Iron DI = Ductile Iron

The quantities shown on the table are limited to those within the UGB. As can be seen from this table, there is a variety of pipe materials in the current storm drainage system. The size of the storm drain pipes vary from 6 to 12 inches in diameter for local systems to 18-inch and larger pipes for major collector systems. Pipe materials include concrete, Poly Vinyl Chloride (PVC), High Density Polyethylene (HDPE), corrugated metal (CMP), cast iron (CI) and ductile iron (DI).

3.4 Typical Storm Drain System Problems

Before addressing particular problems, it is helpful to define the categories of problems likely to be encountered. We have found that problems can generally be divided into the following categories; lack of capacity, end of useful life, lack of facility, lack of maintenance, erosion, and on-site problems. Not all categories of problems are present in every system. A short description of each of these categories follows:

a. Lack of Capacity

This type of drainage problem results from open channels or pipes that are too small to handle the peak storm runoff. This type of problem typically results when upstream development increases the peak flow and volume of runoff, or because the existing system was constructed before storm drainage design standards were established. Therefore, although the storm system may have capacity to handle the runoff from smaller magnitude storms, it is unable to convey the runoff during major storm events. In either case, these portions of the existing system are undersized and need to be improved.

Design standards typically require that as the storm channel or pipe gets larger, it must be designed to convey the flow from a more intense storm event due to the increased risk of property damage should the system fail. For instance, local systems are typically sized based on a 10-year frequency storm, while larger storm drains or ditches serving a major basin must be designed for a 25 or 50 year frequency storm. If the local system overflows, the likelihood of significant property damage is relatively small, while failure of the major systems can result in significant damage to property.

b. On-site Problems

Examples of on-site drainage problems include standing water in yards, flooded driveway culverts on small local systems, flooding in private parking lots and problems related to groundwater and springs. In many cases, the on-site drainage problems are a result of conditions on the site (ie. clogged parking lot catch basins or driveway culverts) that are the responsibility of the private property owner. Evaluation of these types of problems is beyond the scope of this report.

c. End of Useful Life

This type of drainage problem is the result of old, damaged, or worn out systems that no longer function as designed. The most common example of this type of problem includes rusted or collapsed pipes or culverts. The correction of these types of problems requires replacement or reconstruction of the existing system.

d. Lack of Facility

Drainage problems in this category are caused by the absence of a drainage system. Examples include areas where there is no catch basin at the low spot in a street, lack of drainage systems for homes set back from the street, or property which is too low to drain to an established drainage system. Any of these cases typically results in ponding water and/or flooding on a regular basis.

e. Lack of Maintenance

Dirt, gravel, sediment, and other debris carried by storm runoff may settle out or become lodged in culverts, pipes and catch basins, resulting in flooding due to the reduced capacity of the system (sedimentation). This type of problem can be prevented or minimized by routine inspection and cleaning.

A second problem in this category results when ditches or other drainage facilities are located along back lot lines or through undeveloped areas without any provisions for maintenance access. Under this scenario, it is difficult and expensive for the City to maintain the storm drainage facilities on a regular basis, as the costs for obtaining access or restoring the area following maintenance may cost as much as the maintenance work itself.

A final concern under this category is when residents or developers dump debris into ditches during the dry season, which results in flooding when the wet season arrives.

f. Erosion

Unless erosion control measures are maintained during construction of new developments, rainfall washes soil from areas that have been cleared of vegetation and graded for development. Erosion of streambeds and banks may also occur when development increases runoff flows. Deposition of these sediments downstream contributes to the maintenance problems experienced by the system. The irony of erosion problems is that the flooding caused by this sediment typically occurs far downstream of the source of the problem. Although an analysis of this issue is beyond the scope of this report, the City does require erosion control facilities during construction of new developments.

3.5 Mt. Angel Storm Drain System Problem Areas

The major problem areas and their associated categories are summarized in **Table 3-3.** This list shows that there is one primary cause for most of the problems in the City's storm drainage system: lack of capacity. The suspected causes and recommended approaches for correcting these problems are presented in Section 5.

Table 3-3
Existing Drainage Problem Areas
(Based on analysis or City Input)

Location	Problem Category
Major South Trunk Line, Church Street to Garfield Street	Lack of Capacity
Major North Trunk Line, John Street to Garfield Street to Marquam Street	Lack of Capacity
Major North Trunk Line, Marquam Street Culverts at the west City Limits	Lack of Capacity
Major North Trunk Line, from the Marquam Street Culverts southeast to the developed residential area	Lack of Capacity

Finally, while addressing problem areas it should be noted that the City is not currently under any specific regulatory water quality requirements for storm water flows. As such, consideration of storm water quality issues are given limited treatment in this study. At such time that the City comes under regulatory requirements for storm water quality, a storm water management program will need to be developed to address these issues.

3.6 Existing Storm Drainage Funding Mechanisms

According to the City, it does not presently have a dedicated storm drainage system funding mechanism available to finance needed repairs or upgrades to the storm drainage system. Maintenance of the storm drainage system is currently funded from other budgets, such as streets. Potential storm drainage system funding mechanisms are discussed in Section 6.

CITY OF MT. ANGEL
Storm Drainage System Master Plan

Section 4

Hydrologic/Hydraulic Analysis

SECTION 4
HYDROLOGIC/HYDRAULIC ANALYSIS

4.1 Hydrology Analysis Procedure

a. Modeling Methodology

The purpose of the drainage system capacity evaluation was to identify elements of the existing drainage system that cannot accommodate current and/or projected future storm water flows. The calculation of peak flows and runoff volumes within the drainage basins is essential to any storm drainage master planning effort. Peak flows are used to size ditches, culverts and pipe systems during the design process for new facilities. The calculation of peak flows was accomplished using a mathematical computer simulation model, PondPack Santa Barbara Urban Hydrograph (SBUH), developed by Haested Methods. These results were checked using a manual procedure, the Rational Method, as presented in the ODOT Hydraulics Manual.

In addition to the typical advantages provided by computer simulations, the SBUH approach was selected because the rational method is generally considered to be reliable only for basins under 300 acres. Additional differences between the SBUH method and the rational include the use of a 24-hour storm event model with SBUH compared with the Intensity-Duration-Frequency (IDF) tables used in the rational method that end after 6 hours, and a greater variety of soil types in the SBUH. The IDF curves used with the Rational Method generally represent a more intense, shorter duration storm events that work well with site specific storm system designs. However, the 24-hour storm used by SBUH more closely follows the pattern of storms that should be applied to larger, more extensive drainage systems. A brief description of each method is provided below.

Santa Barbara Urban Hydrograph (SBUH) Method

The SBUH procedure involves defining sub-basins of the drainage basin of interest according to two basic hydrologic characteristics, the soil type and the time of concentration, then applying a model storm to that basin. The soil type involves the type of soil (as defined by the Soil Conservation Service soil maps), the use related to the parcel (residential, commercial, various types of agricultural activities, etc.), and judgement of relative quality of soil within that use (good, fair, poor). Using these parameters a CN number was selected to represent each of the various areas within the drainage basin, and used as input in the computer model.

The time of concentration is the length of time it takes for rain falling at the most distant point of a drainage area to travel to the discharge point. Typically, rainfall must travel several segments before it reaches the basin discharge point. These can include an

overland sheet flow segment, a shallow overland segment, open channel segments, and piped segments.

The model storm used is a 24-hour rainfall event, where the total rainfall is distributed in time related increments based on the appropriately selected region of the country. The type of storm used for this study is the Type IA, that represents typical storm patterns for the West Coast from the coastline to the first major mountain range (Cascades, Sierras, etc.). The total rainfall is dependent on the magnitude of the event as described by the expected frequency: 2-year (2.5-inches), 5-year (3.0-inches), 10-year (3.5-inches), 25-year (4.0-inches), 50-year (4.4-inches), or 100-year (4.5-inches). These totals are mapped in the National Oceanic and Atmospheric Administration (NOAA) *Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume X – Oregon*.

To this point, the SBUH and the rational methods are similar. The most significant computational difference between SBUH and rational involves the method of adding together the various sub-basins. For the SBUH the computer calculates a time dependent discharge from each sub-basin, and then adds these results together as the flow is "routed" mathematically along the central drainageway. Using this procedure, the run-off from a sub-basin with a short time of concentration can be properly combined with the run-off from a basin with a much longer time of concentration. Information on the various input parameters used for the SBUH method, are presented in **Appendix C**.

By contrast, the Rational Method as described below is generally used to compute flow from a single area. If you have a large area that can be divided into two small areas, you must compute each area of interest separately. (A large area is not typically the sum of two smaller areas, especially if the smaller areas are are substantially different in size, soil type, or type of development).

The Rational Method

The Rational Method is based on the formula: Q=CIA

where: Q = the runoff rate, cubic feet per second
C= the runoff coefficient, determined by land use
A = the contributing drainage area, acres
I = the rainfall intensity, inches per hour

The basic assumptions for application of the Rational Method are as outlined below, and typically result in conservative but realistic results.

- The computed maximum rate of runoff to the design point is a function of the average rainfall rate during the Time of Concentration (T_c) to that point.

- The maximum rate of rainfall occurs during the time of concentration, and the design rainfall depth during the time of concentration is converted to the average rainfall

intensity for the time of concentration. For Mt. Angel, the Intensity-Duration-Frequency (IDF) curve for Zone 8 should be used.

- The maximum runoff rate occurs when the entire area is contributing flow (ie. at the Time of Concentration).

Table 4-1 presents a comparison between the SBUH and Rational methods for selected hypothetical conditions, including a 10 acre site, and a time of concentration of one hour. Overall this table suggests a reasonable comparability between the predictions of the SBUH and the Rational methods. However, it is important to keep in mind the numerous inputs that affect the results of such calculations. Care must be taken to select an appropriate CN or C number. Probably more importantly, the time of concentration is critical.

As discussed above, the Rational is generally more suited to smaller areas, and it employs a more intense, shorter duration storm. The average increase for Rational over SBUH for all scenarios listed below is approximately 30%. The increase is greater for the 2-year event (ranging from 40-80% increase), and smaller for the 50-year storm (ranging from 0-20% increase). For the storm event of interest in analyzing Mt. Angel's storm drainage system, the 25-year event, the typical increase of Rational over SBUH is approximately 20-30%. While noticeable, this difference is not particularly significant given the overall level of uncertainties associated with estimating storm drainage runoff.

Given this difference, we believe the appropriate course of action is to be conservative when evaluating cases where the capacity of a particular element of the storm drainage system appears marginal when compared to the estimated flows as predicted by SBUH. This conservative approach affects two different areas. First, it should result in giving greater attention to the marginal problem areas, assuming the problem has the potential for being slightly greater than estimated by SBUH. Second, the design process should be slightly more conservative in selecting from the various pipe sizes under consideration. If a particular size appears capable of just handling the flows predicted by SBUH, it may be desirable to go to the next larger pipe size to help ensure the pipe is adequate to handle flows predicted by the Rational method.

Table 4-1 SBUH/Rational Peak Run-Off Comparison (cfs) 10 acre site, Time of Concentration = 1.0 hour				
Storm SBUH Total Rational	2-year 2.5-inches 0.45 in/hr	10-year 3.5-inches 0.64 in/hr	25-year 4.0-inches 0.75 in/hr	50-year 4.4-inches 0.84 in/hr
Agricultural (CN = 82, C = 0.40)				
CN = 82	1.01	2.10	2.70	3.20
C=0.40	1.80	2.56	3.00	3.36
Residential (RS: CN = 84, C = 0.50; RM: CN = 91, C = 0.70)				
CN = 84	1.22	2.38	3.01	3.53
C = 0.50	2.25	3.20	3.75	4.20
CN = 91	2.12	3.49	4.18	4.74
C = 0.70	3.15	4.48	5.25	5.88
Urban (I: CN = 91, C = 0.70; CR: CN = 92, C = 0.70, CG: CN = 94, C = 0.80)				
CN = 91	2.12	3.49	4.18	4.74
C = 0.70	3.15	4.48	5.25	5.88
CN = 92	2.27	3.65	4.35	4.92
C = 0.70	3.15	4.48	5.25	5.88
CN = 94	2.58	3.99	4.69	5.25
C = 0.80	3.60	5.12	6.00	6.72

b. Design Storm Frequency

The selection of the design storm requires the determination of the degree of protection desired from the storm drainage system. A design storm with a low probability of being exceeded, such as the 100-year design storm (1% chance of being exceeded any given year), provides a high degree of safety in the drainage system design. However, the cost of such a system is relatively high compared to a system based on a design storm with a high exceedance probability. On the other hand, a system designed for a 2-year storm (50% chance of being exceeded any given year) will result in a lower cost drainage system whose capacity will be exceeded every few years, with possible property damage, public inconvenience and personal hazard.

To determine a design storm for drainage planning purposes, the following factors must be considered:

- The cost of the additional level of protection (ie. sizing system to convey a larger storm)

- The size of the drainage basin
- The extent of probable property damage if the system fails
- The availability of storage within the drainage system.

The size of the drainage area has a dramatic impact on the recommended level of protection. As the size of the drainage area increases, so does the total amount of runoff. As previously noted, design standards typically require that as the storm channel or pipe gets larger, it must be designed to convey the flow from a more intense storm event due to the increased risk of property damage should the system fail.

For illustrative purposes, consider that if a small local system overflows, the likelihood of significant property damage is relatively small, while failure of the major systems can result in significant damage to property. Conversely, if the drainage facilities of a large drainage basin (such as one with 50 times the flow of smaller basins) is undersized by as little as 10%, those excess flows will be five times greater than the entire flow through the small basin, and may produce serious flooding damage.

Under certain circumstances, a detailed cost-benefit analysis may be appropriate for determining the appropriate magnitude storm to be used. As an example, a large construction project in or near a floodplain, might warrant a study of the cost of conveying various quantities of stormwater compared to the expected cost of damage for each additional incremental rise in floodwater elevation. However, such an analysis is generally beyond the scope of a report such as this. Instead, standard guidelines relating the magnitude of storm to be considered to the various portions of a storm drainage system are commonly used.

With all these factors in mind, **Table 4-2** outlines the design storm frequencies typically employed in storm system analysis, and thus utilized for this report. This level of protection is consistent with other Cities in the Willamette Valley and the City's Public Works Design Standards.

Table 4-2
Design Storm Frequency

Area	**Frequency**
Residential areas	10-year storm
Commercial and high value districts	10-year storm
Trunk lines (18" pipe and larger)	25-year storm
Minor creeks and drainage ways (not shown as a flood plain on the Flood Insurance Rate Map (FIRM))	50-year storm
Major creeks (shown as a flood plain on the FIRM)	100-year storm

Based on this Table, the analysis performed for this study used 10-year and 50-year storm events. The 10-year storm provided values relevant to peak flows from individual sub-basins that can be used to help size future piped or roadside systems.

4.2 Hydraulic Analysis

a. General

A typical public storm drainage system generally consists of three main elements; pipes, culverts, and open channels (manmade ditches or natural streams). While other elements exist, such as pumps, dams, ponds, and water quality features, the pipes, culverts, and open ditches serve as the primary means of conveying stormwater through and out of the City.

The following sections provide a brief summary of the standard mathematical analysis used to determine the capacity of a given element. Like a chain, a storm drainage system is only as good as its weakest link. Thus, in completing an analysis of a storm drainage system it becomes necessary, as a minimum, to evaluate all of the major elements to identify any "weak link." For this study the evaluation included all major trunk lines down to those that handle the drainage for at least a full sub-basin. Local collection systems within a sub-basin were not specifically addressed.

b. Pipe Flow - Manning's Formula

A large majority of Mt. Angel's storm drainage system is made up of pipe elements. The drainage is collected by an inlet structure, such as a catch basin, and conveyed from point to point through a series of pipes connected by structures, such as manholes or junction boxes. Most pipes within the storm drainage system were assumed to be flowing full under open channel flow conditions. ("Open Channel" in a pipe system refers to uniform gravity flow in a long pipe segment, not open to the air such as a ditch).

In most areas of Mt. Angel, the storm system is flat enough that significant surcharge cannot be developed at most inlets and therefore this is a reasonable and conservative assumption. The formula used to evaluate pipes under these circumstances is Manning's Formula, which is expressed as:

$$Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2}$$

where: Q = flow, cubic feet per second
A = cross-sectional area, square feet
R = hydraulic radius, feet
S = slope, feet/feet
n = Manning roughness coefficient

The roughness factor for pipes varies according to the material used and the age of the pipe material. For this planning effort, a minimum "n" value of 0.013 shall be used in Manning's formula for the design of all smooth wall storm pipes regardless of pipe material. In theory, new PVC sewers have manufacturer's "n" value of as low as 0.009. However, sand and grit as well as slime accumulations on the pipe walls over time tend to render a true, or operational, "n" value of 0.013. Hence, an "n" value of less than 0.013 for smooth wall pipe is not recommended for design purposes. For corrugated pipes an "n" of 0.024 value was used, and is recommended for design purposes.

Using the equation above it becomes a straightforward matter to calculate the capacity of any given pipe segment given a few simple, specific pieces of information. The cross sectional area can be readily computed from the pipe diameter. The hydraulic radius is defined as the cross sectional area divided by the wetted perimeter and is included in the formula because the friction resistance opposing the flow occurs at the wetted perimeter. For this study the interest is in the maximum capacity of the pipe, so all pipes are assumed to be flowing full. The slope is self explanatory, and as the “n” value is discussed above. **Table 4-3** presents the computed capacity of a variety of pipe sizes and slopes assuming the pipes have a Manning’s “n” of 0.013 and are flowing full:

Table 4-3
Pipe Capacity, Flowing Full (cfs)
Manning’s “n” = 0.013

Slope (%)	Pipe Size (inches)						
	12	18	24	30	36	42	48
0.2	2	5	10	18	30	45	64
0.4	2	7	14	26	42	64	91
0.6	3	8	18	32	52	78	112
0.8	3	9	20	37	60	90	129
1	4	11	23	41	67	101	144
1.2	4	12	25	45	73	111	158
1.4	4	12	27	49	79	119	170
1.6	5	13	29	52	85	128	182
1.8	5	14	30	55	90	135	193
2	5	15	32	58	95	143	204
2.2	5	16	34	61	99	150	214
2.4	6	16	35	64	104	156	223
2.6	6	17	37	66	108	163	232
2.8	6	18	38	69	112	169	241
3	6	18	39	71	116	175	249

c. Culvert Flow

Culverts are distinguished from pipes in that they are open at both ends, rather than connected to structures such as catch basins or manholes. Culverts function under several distinct conditions depending on the depth of flow at their upstream and downstream ends. The desired condition for a properly sized channel and culvert is to have the downstream water surface level below the top of the pipe, and the upstream water surface level at or below the top of the pipe. In this condition the culvert is not having any significant impact on the flow, and is simply conveying the water underground from one section of channel to another.

If the downstream channel water surface level is below the top of the culvert, but the flow from upstream is greater than the full flow capacity of the culvert, the water surface height at the upstream end will rise. This will increase the water pressure at the upstream end, which will then force water through the pipe at a higher rate. This condition is described as inlet control. Under this condition the water surface elevation will stabilize at the point where the water is being forced through the culvert at the same rate that it is arriving from upstream.

If the downstream channel is undersized, the normal depth of flow will rise above the top of the outlet pipe. In order for water to continue to flow through the pipe, the water at the upstream end must rise also. This condition is described as outlet control. Since outlet control also results in a higher than normal upstream water surface elevation, it is generally considered to be an undesirable condition and should be corrected whenever possible.

Both inlet and outlet control capacities are frequently determined using nomographs that allow a simple, graphical solution for a wide range of pre-computed conditions. Sample nomographs for concrete and corrugated metal pipes for both inlet and outlet control are presented in **Appendix D.**

The final condition that may be relevant to culvert flow is that of a pipe flowing full. Just as open channels have a “normal” condition, so do pipes. The physical properties of a pipe define its capacity in the absence of bends, obstructions, changes in size, etc. This is described in more detail in the following section.

d. Open Channel Flow - Manning's Formula

With the exception of some roadside ditches, and some open channels at the very upper and lower ends of the system, the Mt. Angel storm drainage system makes little use of open drainageways. The following discussion is provided for completeness, and as a resource to aid in the evaluation of any open drainageways that might be proposed in the future.

Any analysis of open ditches should address at least two main issues. The first is the ability of the ditch to carry the anticipated flows. The second, and more subtle consideration, is ensuring that they are properly designed to accept flows from piped systems or other ditches discharging to them. If the water surface in the ditch becomes too high, water in piped systems or adjacent roadside ditches tends to back up and resist the flow of water trying to enter the main ditch. If such a situation occurs frequently, the slow drainage in the piped system can allow sediment to settle out and accumulate, thereby creating further reductions in system capacity as well as maintenance problems.

Under conditions described as "normal flow", the depth of water in an open ditch can be determined using Manning's equation:

$$Q = \frac{1.486}{n} \times [Y \times (B + Z \times Y)] \times \{\frac{[Y \times (B + Z \times Y)]}{[B + 2Y \times (1 + Z^2)^{1/2}]}\}^{2/3} \times S^{1/2}$$

where:	Q =	Flow (cfs)
	n =	Manning's coefficient (0.035 used for open channel with a natural bottom, 0.013 used for open channel with a concrete bottom)
	Y =	Flow Depth (feet)
	B =	Channel Bottom Width (feet)
	Z =	Channel Side Slopes (Z horizontal: 1 Vertical)
	S =	Channel Slope (ft/ft)

Normal flow occurs where the ditch or waterway is consistent, with no changes in slope, no bends, or obstructions such as culverts or weirs. While normal flow is a best case situation, it provides a reliable estimate for flow depth at a given flow volume for man-made channels with consistent cross sections and gradual bends.

When an open drainageway encounters a culvert, the effect on the flow is dependent on the flow relative to the size and capacity of the culvert. If culvert capacity is large relative to the flow, it is unlikely that it will have a significant impact on the open channel flow in the ditch. However, if the flow in the ditch approaches or exceeds the capacity of the culvert, the conditions for normal flow can be violated and other methods must be applied to estimate the depth of flow in the ditch.

While the details of the culvert flow were described in the preceding section, the primary effect of an undersized culvert on open channel flow is to raise the water surface elevation on the upstream end of the culvert. This higher water surface elevation impedes normal flow for some distance upstream of the culvert. This upstream region is described by a backwater curve that can be calculated either by hand or computer programs.

For the purposes of this study, backwater analysis was not conducted. It is important that culverts on the main drainage channels not be points of flow restrictions that cause significant backwater conditions.

4.3 Computed Stormwater Flows for Existing Conditions

The baseline for analysis in this study are the existing conditions. Using the CN values for current zoning, land uses, and estimated conditions, the various basins were modeled under 25-year storm event conditions. Where the current use does not match the zoning, such as land still being farmed in the RS zone, the CN for the actual use was employed in the study for existing conditions. Where there is a mixture of uses, a CN based on a weighted average was computed. The CN numbers used in this modeling are shown in **Table 4-4**.

Table 4-4
Typical Sub-basin CN Parameters

Zone	CN
RS – Single Family Residential	84
RM – Multi-Family Residential	91
I – Industrial	91
CR – Commercial Residential	92
CG – Commercial General	94
Public	Varies
EFU/Farm Use	82
RL – Light Residential, UGB	84
RH – High Residential, UGB	91
I – Industrial, UGB	91

With possible CN numbers ranging from 30 or less for well drained, sandy meadows to 98 for paved surfaces, the numbers used in this study are restricted to a relatively narrow range. This is due to the generally impervious nature of the native soil in and around Mt. Angel. In areas where the natural soil drains readily, there can be a large change in CN number from undeveloped to developed conditions.

The time of concentration was estimated for each basin in three segments; overland sheet flow, shallow overland flow, and piped or open channel flow. For overland sheet flow, the ground slope, soil condition and flow length was estimated based on typical parameters for each area. **Table 4-5** shows representative values for these parameters used in this study.

Table 4-5 Typical Sub-basin Time of Concentration Parameters Time in Hours (Minutes)			
Overland Sheet Flow			
	100’	150’	200’
n = 0.05			
s = 2%	0.08 (5)	0.11 (6)	0.13 (8)
s = 1%	0.10 (6)	0.14 (8)	0.17 (11)
n = 0.08			
s = 2%	0.11 (7)	0.15 (9)	0.19 (12)
s = 1%	0.15 (9)	0.20 (12)	0.26 (16)
n = 0.15			
s = 2%	0.18 (11)	0.26 (15)	0.32 (19)
s = 1%	0.24 (14)	0.34 (20)	0.42 (25)
n = 0.24			
s = 2%	0.27 (16)	0.37 (22)	0.47 (28)
s = 1%	0.36 (21)	0.49 (29)	0.62 (37)
Manning’s coefficients used as follows: 0.05 – Industrial and General Commercial; 0.08 – Residential Multiple and Commercial Residential; 0.15 – Combination Areas; 0.24 – Residential Single and Public (Schools and Parks)			
Shallow Concentrated Flow			
	Paved	Unpaved	
s = 4%	N/A	0.009 (0.5)	
s = 2%	0.010 (0.6)	0.012 (0.7)	
s = 1%	0.014 (0.8)	0.017 (1.0)	
Times shown are per 100 foot of distance traveled.			
Pipe Flow			
6 ft/sec assumed average velocity.			

4.4 Computed Stormwater Flows for Future Conditions

The same values listed above were also used for calculating stormwater run-off under future conditions. However, rather than representing a sub-basin by CN numbers and times of concentration based on the current state of development, all zones were assumed to be fully developed according to their respective zoning conditions. **Table 4-6** provides a summary of CN and time of concentration for all sub-basins in both existing and future conditions.

Table 4-6 Sub-basin Characteristic Summary					
		CN		Time of Concentration (hours)	
Sub-basin	Size (acres)	Existing	Future	Existing	Future
N1	19	81	84	0.52	0.52
N2	19	85	91	0.42	0.22
N3	22	82	84	0.67	0.30
N4	16	90	90	0.30	0.30
N5	9	91	93	0.30	0.30
N6	50	85	91	0.82	0.42
N7	13	89	90	0.32	0.32
N8	8	95	95	0.22	0.22
N9	32	89	91	0.55	0.38
N10	37	85	89	0.62	0.38
N11	44	88	88	0.32	0.32
N12	23	84	85	0.32	0.32
N13	67	83	87	0.78	0.72
N14	25	86	86	0.33	0.33
S1	16	82	84	0.65	0.40
S2	44	85	86	0.73	0.57
S3	28	84	86	0.72	0.55
S4	25	91	92	0.23	0.23
S5	17	95	95	0.17	0.17
S6	33	87	87	0.57	0.32
S7	17	83	85	0.47	0.33
S8	46	85	86	0.37	0.37
S9	90	83	84	0.67	0.67
NW	117	83	85	1.22	0.93
E	39	86	88	0.53	0.37
SW1	19	83	85	0.77	0.30
SW2	26	84	84	0.40	0.40

4.5 Computed SBUH Hydrographs

The SBUH stormwater hydrographs computed based on the input parameters listed above are included in this report as **Appendix E**. The peak flow values from these calculations are used in Section 5 to evaluate the adequacy of the main trunk lines and culverts.

CITY OF MT. ANGEL
Storm Drainage System Master Plan

Section 5

Storm System Evaluation & Recommendations

SECTION 5
STORM SYSTEM EVALUATION & RECOMMENDATIONS

5.1 Introduction

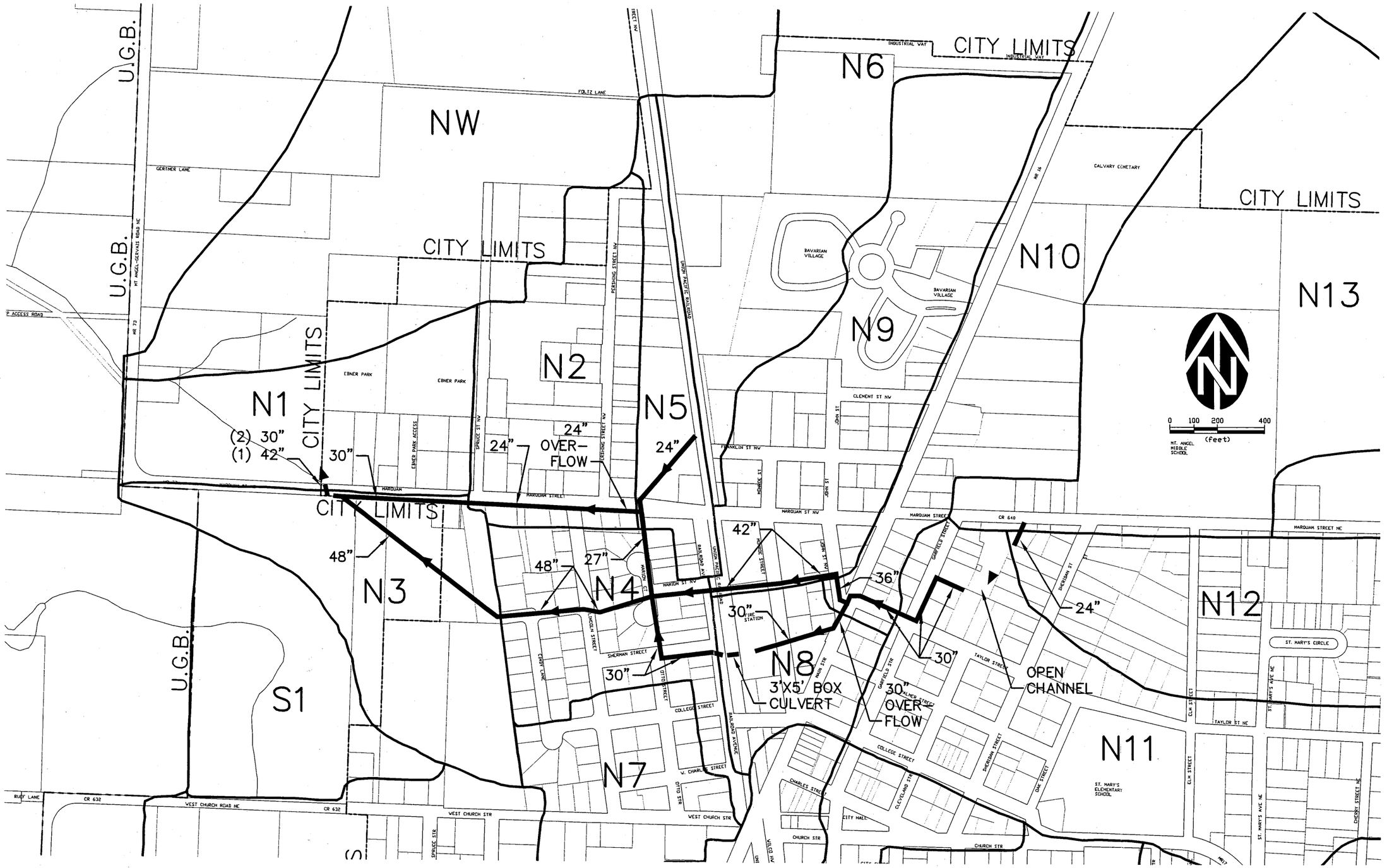
In the previous sections, we presented the background information and methodology used in completing the analysis of Mt. Angel's stormwater system. In this section we bring the pieces together to identify shortcoming's in the stormwater system, and then make recommendations to correct those problems. The remainder of this section is organized as follows:

- North Basin Evaluation
- South Basin Evaluation
- Stormwater Drainage System Capital Improvement Plan (CIP) Elements
- Minor Basins
- Stormwater Detention
- Local Problem Areas
- Recommended Improvements

5.2 North Basin Evaluation

As discussed in Section 3, the North Basin is estimated to consist of approximately 384 acres, which has been divided into fourteen sub-basins for the purposes of this study. The North Basin is drained by a complex network of pipes which includes a main trunk line and several overflow routes.

The primary storm drain trunk line for the North Basin, shown in **Figure 5-1**, ends at Marquam Street near the west City Limits. At this location, the line is a 48" diameter concrete pipe that angles southeast towards an unnamed right-of-way 500' south of Marquam Street. The line then runs east, sometimes in the unnamed public right-of-way and in Marion Street, and at other times through easements on private property, to John Street. Along the way, it decreases to a 42" pipe at Marion Court. At John Street it decreases to a 36" pipe and jogs south to Taylor Street. At Taylor Street the line decreases to a 30" pipe and turns east until it gets to Garfield Street, where it turns north for a couple of hundred feet before making one last turn east into private property to pick up drainage from an open ditch.



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CITY OF MT. ANGEL, OREGON

MT. ANGEL STORM DRAIN MASTER PLAN

NORTH BASIN MAJOR STORM TRUNK LINES

FIGURE 5-1

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Figure 5-1 also includes the major overflow routes. One overflow route runs along Marquam Street from east of Pershing Street to the west City Limits. The other major overflow route runs between the intersection of Main & Taylor Streets south of the main trunk line over to Sherman Street where it turns north and rejoins the main trunk line at the intersection of Marion Street and Marion Court.

Using the defined sub-basins and the storm drain network depicted in **Figure 5-1**, we analyzed the run-off for the North Basin using the Santa Barbara Urban Hydrograph (SBUH) computer model as implemented by Haested Methods in their PondPack software package. The results of this analysis is summarized and discussed in the following sections.

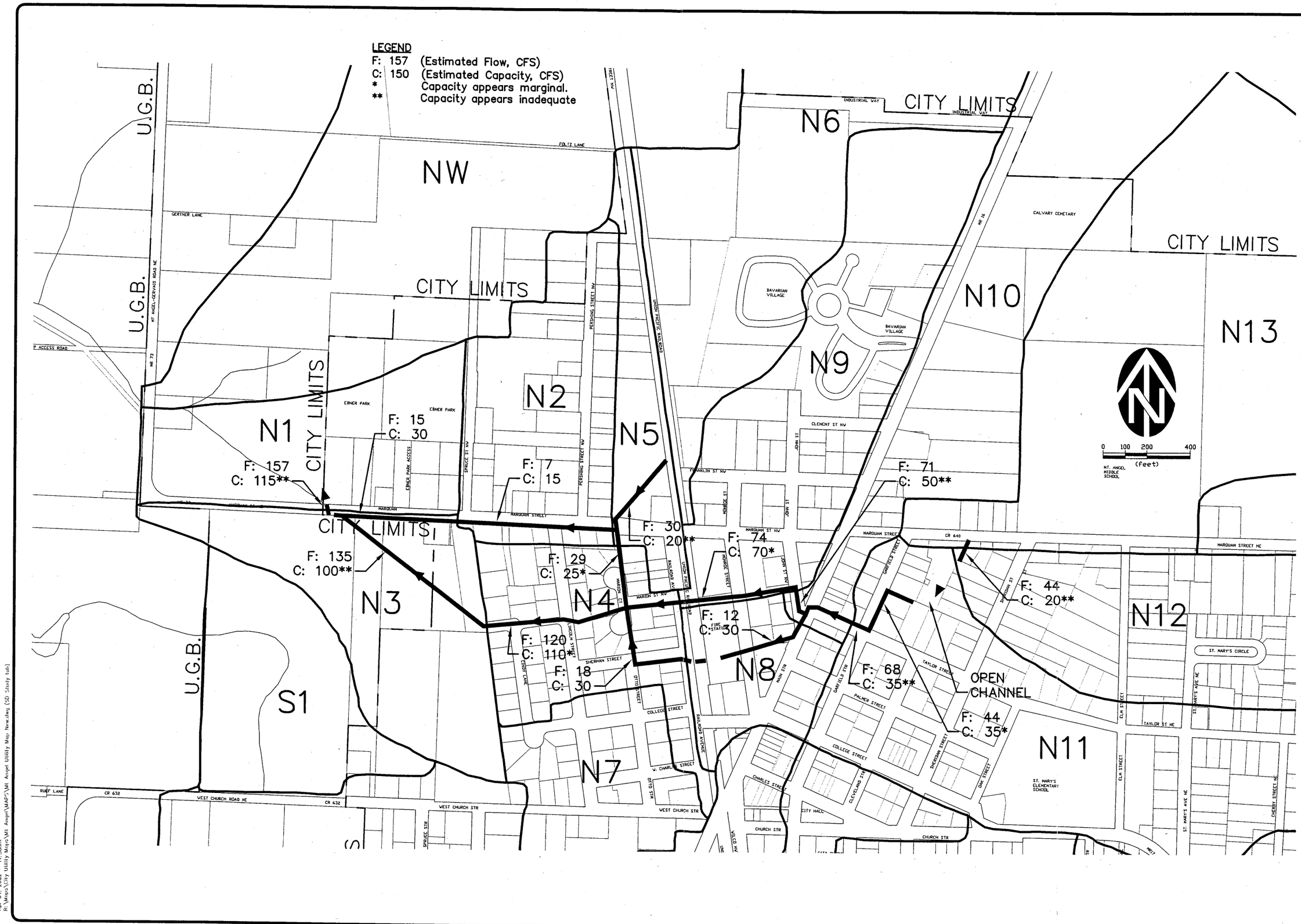
a. North Basin Existing Conditions

Table 5-1 presents a summary of the results of the SBUH calculations for the North Basin under existing conditions.

Table 5-1
SBUH Calculation Summary
North Basin – Existing Conditions

Sub-Basin	Size (acres)	CN	Tc (Hours)	Q (cfs)
N1	19	81	0.52	6
N2	19	85	0.42	9
N3	22	82	0.67	7
N4	16	90	0.30	10
N5	9	91	0.30	6
N6	50	85	0.82	18
N7	13	89	0.32	8
N8	8	95	0.22	7
N9	32	89	0.55	16
N10	37	85	0.62	14
N11	44	88	0.32	25
N12	23	84	0.32	10
N13	67	83	0.78	21
N14	25	86	0.33	13

The calculated run-off (Q) from the table above is also shown on **Figure 5-2**, along with the flows as they were calculated through the storm drain pipe network. The sub-basin run-off is listed immediately below the sub-basin number. The black circles are calculation nodes where flows from sub-basins and upstream pipes are added together. The flow at a node is shown by a callout leader pointing to the node. Flow between the nodes is shown by arrows, with the rate of flow listed either above or below the flow arrow.



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CITY OF MT. ANGEL, OREGON

MT. ANGEL STORM DRAIN MASTER PLAN

NORTH BASIN
EXISTING FLOW & CAPACITY
MAJOR TRUNK LINES

FIGURE 5-3

SHEET 1 OF 1

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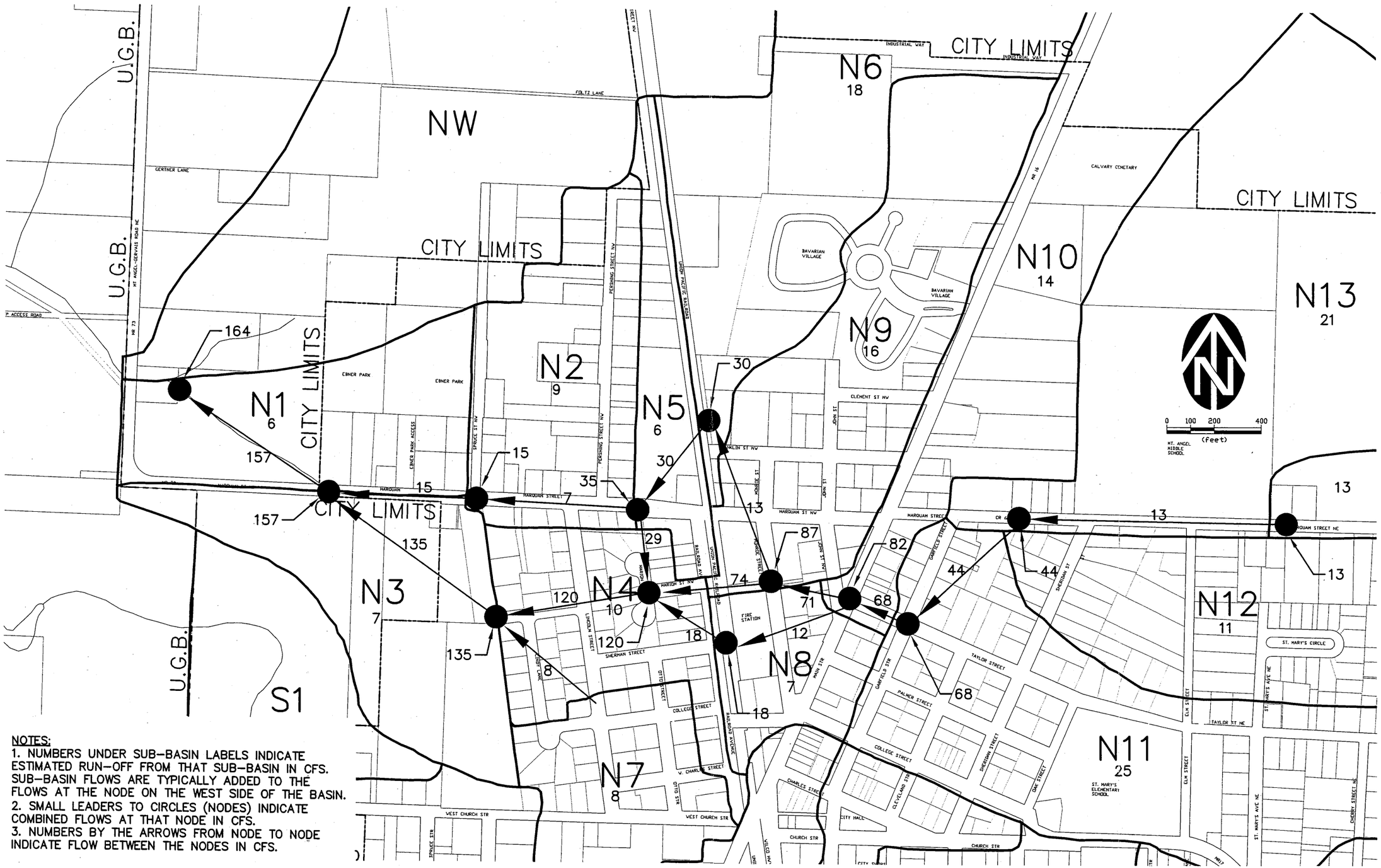
As an example, the node at the intersection of Garfield and Taylor Streets shows that the SBUH model estimates that there would be 68 cfs passing this point in a 25-year storm event under existing conditions. This 68 cfs would be the result of the combination of the 44 cfs shown arriving from the northeast from Marquam Street and the 25 cfs generated by sub-basin N11. The 68 cfs is then routed to the west to the next node at the intersection of Main and Taylor Streets. At this location, the flow from sub-basin N10 joins to result in a combined flow at the node of 82 cfs. Since this location is one of the points where an overflow route diverges from the main line, 71 cfs is shown routed in the main trunk line to the northwest to Monroe Street northeast of the fire station, while 12 cfs is routed to the southwest in the overflow line.

In reviewing the combination and division of flows at the nodes, it becomes readily apparent that the totals are not exactly equal to that shown for the node. For example, at Garfield and Taylor the 44 cfs from the northeast and the 25 cfs from sub-basin N11 (total = 69 cfs) do not equal the 68 cfs shown at the node. There are two reasons why such discrepancies occur. One is simply due to rounding, where the fractional parts of the numbers combine together to create a result that rounds either up or down from the direct sum of the whole number parts.

The other reason has to do with the timing of the combination of the flows. As has already been shown in prior sections, the time of concentration for the basins differ widely. This results in the flows for the basins reaching their peak at different times. Thus, at a node where the flows from a basin with a short time of concentration adds to flows that result from a longer time of concentration, the flows from the short time of concentration area have already passed their peak and decreased before the main flows reach their peak. **Appendix E** presents graphs of the combined flow at selected locations along the main trunk line.

Once the SBUH computations were completed, the next step is to check the estimated flows against the estimated capacity of the various sections of storm drain pipe. This comparison is shown on **Figure 5-3**. In this figure the various key segments of the storm drain trunk and overflow lines are labeled with "F" designating the estimated flow, and with "C" designating estimated capacity. Where the match between capacity and flow is relatively close (keeping in mind both the general accuracy of estimating storm run-off, and the comparison of SBUH and Rational from Section 4) the capacity is noted with an asterisk (*). If the capacity is significantly below the estimated flows the capacity is marked with a double asterisk (**).

The specific break points for the capacity designations (*) and (**) are somewhat arbitrary. In general, if the flow and capacity were within 20-25% of each other a single asterisk (*) was used. When flow exceeded capacity by more than this amount, the double asterisk (**) was employed. The segments of pipe identified as either marginal or inadequate are also summarized in **Tables 5-2** and **5-3**, respectively.



NOTES:
1. NUMBERS UNDER SUB-BASIN LABELS INDICATE ESTIMATED RUN-OFF FROM THAT SUB-BASIN IN CFS. SUB-BASIN FLOWS ARE TYPICALLY ADDED TO THE FLOWS AT THE NODE ON THE WEST SIDE OF THE BASIN.
2. SMALL LEADERS TO CIRCLES (NODES) INDICATE COMBINED FLOWS AT THAT NODE IN CFS.
3. NUMBERS BY THE ARROWS FROM NODE TO NODE INDICATE FLOW BETWEEN THE NODES IN CFS.

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CITY OF MT. ANGEL, OREGON
MT. ANGEL STORM DRAIN MASTER PLAN

NORTH BASIN SBUH ESTIMATED FLOWS EXISTING CONDITIONS

FIGURE 5-2

SHEET 1 OF 1

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Table 5-2 North Basin – Existing Conditions Marginal Pipe Segments (25-yr Storm)				
Pipe Location	Dia. (inches)	Est. Flow (cfs)	Est. Capacity (cfs)	Comments
Marquam St to Marion Ct	27	29	25	Surcharges
Marion St alignment at W. City Limits	48	120	110	Surcharges
Marion St alignment Marion Ct to John St	42	74	70	Surcharges
Garfield St N. of Taylor St	30	44	35	Surcharges

Table 5-3 North Basin – Existing Conditions Inadequate Pipe Segments (25-yr Storm)				
Pipe Location	Dia. (inches)	Est. Flow (cfs)	Est. Capacity (cfs)	Comments
Marquam St. culverts at W. City Limits	(2) 30 (1) 42	157	115	Additional capacity required
S. of Marquam St at W. City Limits	48	135	100	Old parallel 24" may carry some overflow. May only surcharge.
Marquam St to RR tracks	24	30	20	Additional capacity required
John St N. of Main St	36	71	50	Additional capacity required
Taylor St Garfield St to Main St	30	68	35	Additional capacity required
Marquam St to open ditch W. of Sheridan St	24	44	20	Additional capacity required

b. North Basin Future Conditions

Table 5-4 presents a summary of the results of the SBUH calculations for the North Basin under future, fully developed, conditions.

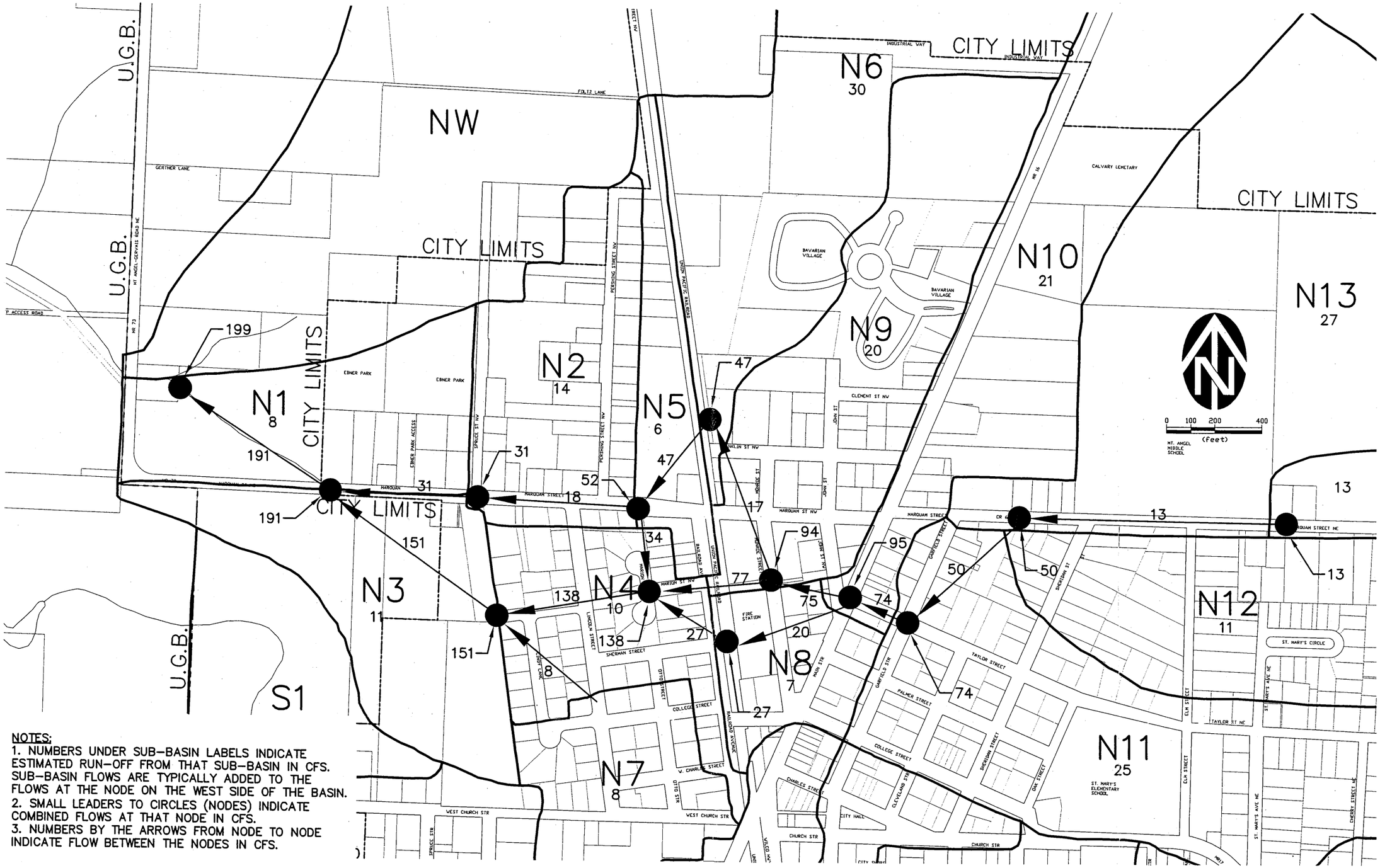
Table 5-4
SBUH Calculation Summary
North Basin – Future Conditions

Sub-Basin	Size (acres)	CN	Tc (Hours)	Q (cfs)	% Increase over exist.
N1	19	84	0.52	8	33%
N2	19	91	0.22	14	56%
N3	22	84	0.30	11	57%
N4	16	90	0.30	10	0%
N5	9	93	0.30	6	0%
N6	50	91	0.42	30	67%
N7	13	90	0.32	8	0%
N8	8	95	0.22	7	0%
N9	32	91	0.38	20	25%
N10	37	89	0.38	21	50%
N11	44	88	0.32	25	0%
N12	23	85	0.32	11	10%
N13	67	87	0.72	27	29%
N14	25	86	0.33	13	0%

The calculated run-off (Q) from the table above is also shown on **Figure 5-4**, along with the flows as they were calculated through the storm drain pipe network. For a discussion of the composition of, and methodology behind, the figures and tables in this section, the reader may find it useful to review Section 5-2a North Basin Existing Conditions. The remainder of this section will be predominantly limited to a presentation of information without a reiteration of background information.

In reviewing **Table 5-4**, the percent increase from existing conditions run-off to future conditions varies significantly. In general, the larger increases are the larger sub-basins on the perimeter of the City, while those showing little or no increase are found in the fully developed areas in the middle of town. As these sub-basins combine, the typical result is an increase demand on the major trunk line system of 10-20%. However, because the major trunk lines are generally at capacity, the increase in demand for the overflow routes is much higher, on the order of 50-100% or more.

Figure 5-5 provides the direct comparison of estimated flow with estimated capacity and identifies pipe segments that are marginal or inadequate. This information is also summarized in **Tables 5-5** and **5-6**.



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CITY OF MT. ANGEL, OREGON

MT. ANGEL STORM DRAIN MASTER PLAN

NORTH BASIN
SBUH ESTIMATED FLOWS
FUTURE CONDITIONS

FIGURE 5-4

SHEET 1 OF 1

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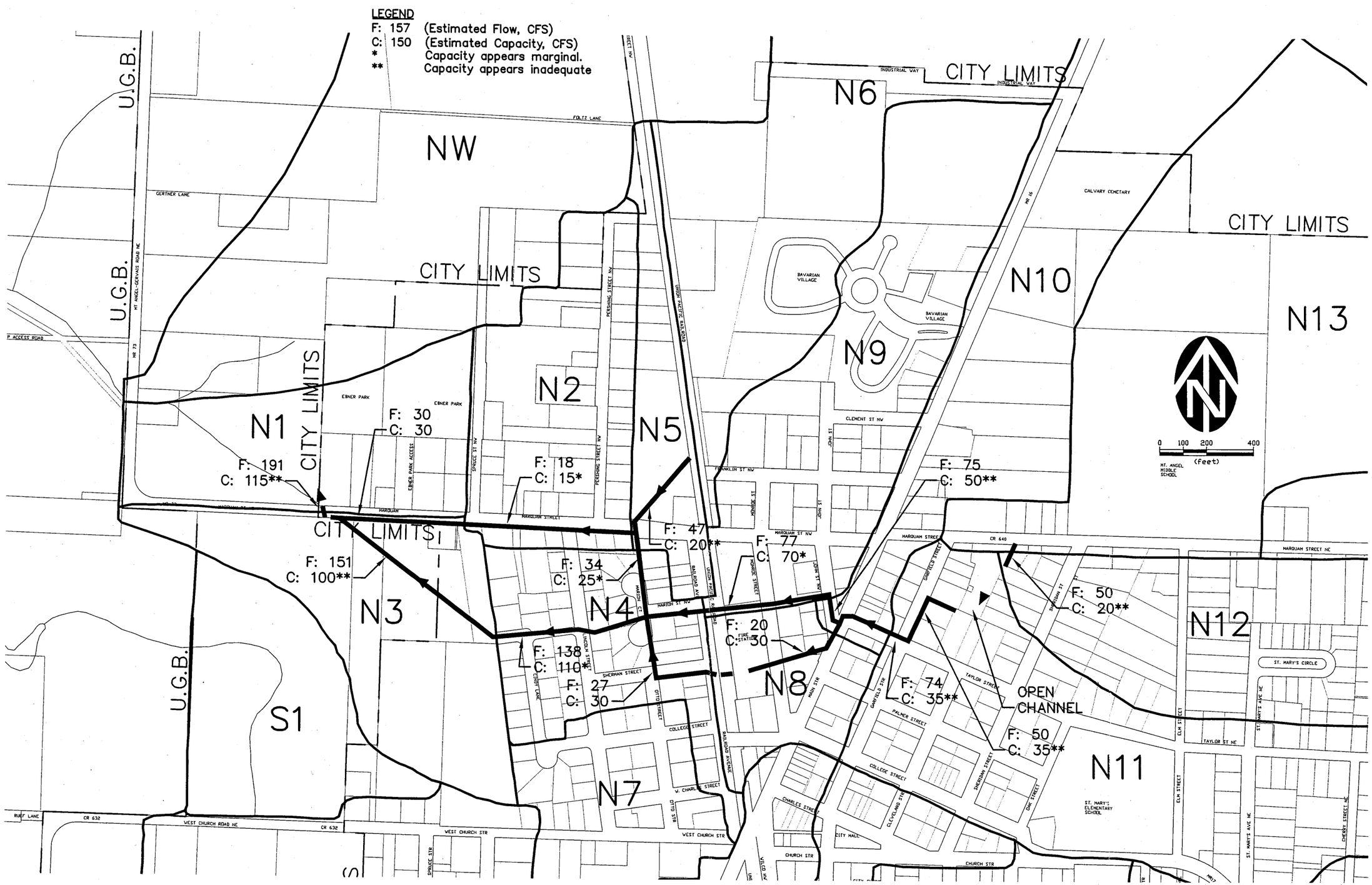

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CITY OF MT. ANGEL, OREGON

MT. ANGEL STORM DRAIN MASTER PLAN

NORTH BASIN FUTURE FLOW & CAPACITY MAJOR TRUNK LINES

FIGURE 5-5

SHEET 1 OF 1

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Table 5-5 North Basin – Future Conditions Marginal Pipe Segments (25-yr Storm)				
Pipe Location	Dia. (inches)	Est. Flow (cfs)	Est. Capacity (cfs)	Comments
Marquam St, Pershing St to Spruce St	24	18	15	(+) Surcharges
Marquam St to Marion Ct	27	34	25	Surcharges
Marion St alignment at W. City Limits	48	138	110	Surcharges
Marion St alignment Marion Ct to John St	42	77	70	Surcharges
(+) Indicates new to this category compared to Existing Conditions.				

Table 5-6 North Basin – Future Conditions Inadequate Pipe Segments (25-yr Storm)				
Pipe Location	Dia. (inches)	Est. Flow (cfs)	Est. Capacity (cfs)	Comments
Marquam St. culverts at W. City Limits	(2) 30 (1) 42	191	115	Additional capacity required
S. of Marquam St at W. City Limits	48	151	100	Old parallel 24" may carry some overflow. Additional capacity required
Marquam St to RR tracks	24	47	20	Additional capacity required
John St N. of Main St	36	75	50	Additional capacity required
Taylor St Garfield St to Main St	30	74	35	Additional capacity required
Garfield St N. of Taylor St	30	50	35	(+) Additional capacity required
Marquam St to open ditch W. of Sheridan St	24	50	20	Additional capacity required
(+) Indicates new to this category compared to Existing Conditions.				

c. North Basin Recommended Improvements

As discussed above, the pipe segments in Table 5-2 and Table 5-5 appear to be generally adequate for the estimate flows, though surcharging may occur in some cases. Unless other conditions develop, such as degradation due to aging, these pipe segments should not need to be upgraded. The remainder of this section presents the recommended improvements to correct the problem areas identified in Table 5-3 and Table 5-6.

Working from west to east, the first recommended improvement is the addition of a 48-inch diameter culvert across Marquam Street. The existing twin 30-inch and single 42-inch culverts are estimated to have a capacity of 115 cfs, based on the limitations of inlet control. The 48-inch would add roughly 80 cfs, bringing the total capacity to 195 cfs, consistent with the 191 cfs estimated flow for this location.

The next area of concern is the long run of 48-inch pipe that runs to the southeast from the area of the Marquam Street culvert crossing. This pipe segment is estimated to have a current capacity of roughly 100 cfs, while flows are expected to eventually reach 151 cfs. For this pipe segment there may be the potential to have a temporary, interim improvement by making use of the existing 24-inch pipe that lies just to the west of the 48-inch pipe. If this pipe were connected to the 48-inch, it could carry an additional 20 cfs, bringing the total capacity of this segment to roughly 120 cfs. While this is not adequate for a permanent solution, with additional capacity gained through surcharging, the combination of the 48-inch and 24-inch would come close to the required total capacity, and as such could prove sufficient for some time into the future. To provide the full capacity necessary for this segment the 24-inch should be replaced by a 36-inch pipe immediately adjacent to the existing 48-inch pipe.

The existing 24-inch running from Marquam Street east of Pershing Street to the northeast to the railroad tracks is significantly undersized to carry the estimated flows. This pipe should be replaced with a 36-inch pipe if run in the same alignment. If the route of this pipe is changed to eliminate impacts to development, the pipe should be sized to carry the estimated 47 cfs. Given the location of this pipe, and the minimal impacts it appears to have on the overall function of the North Basin system, and on adjacent properties, it may be acceptable to delay its replacement until development of the affected property, or until increased run-off creates problems, whichever is earlier.

The remainder of the major problem areas in the North Basin occur starting at John Street and work their way east in Taylor Street, then Garfield Street, and finally through open drainage up to Marquam Street. While it would be feasible to correct these problems by replacing the undersized lines with larger lines in the same alignment, we recommend constructing a new 36-inch line starting in John Street north to Marquam Street, then east to the west property line of the Mt. Angel Middle School.

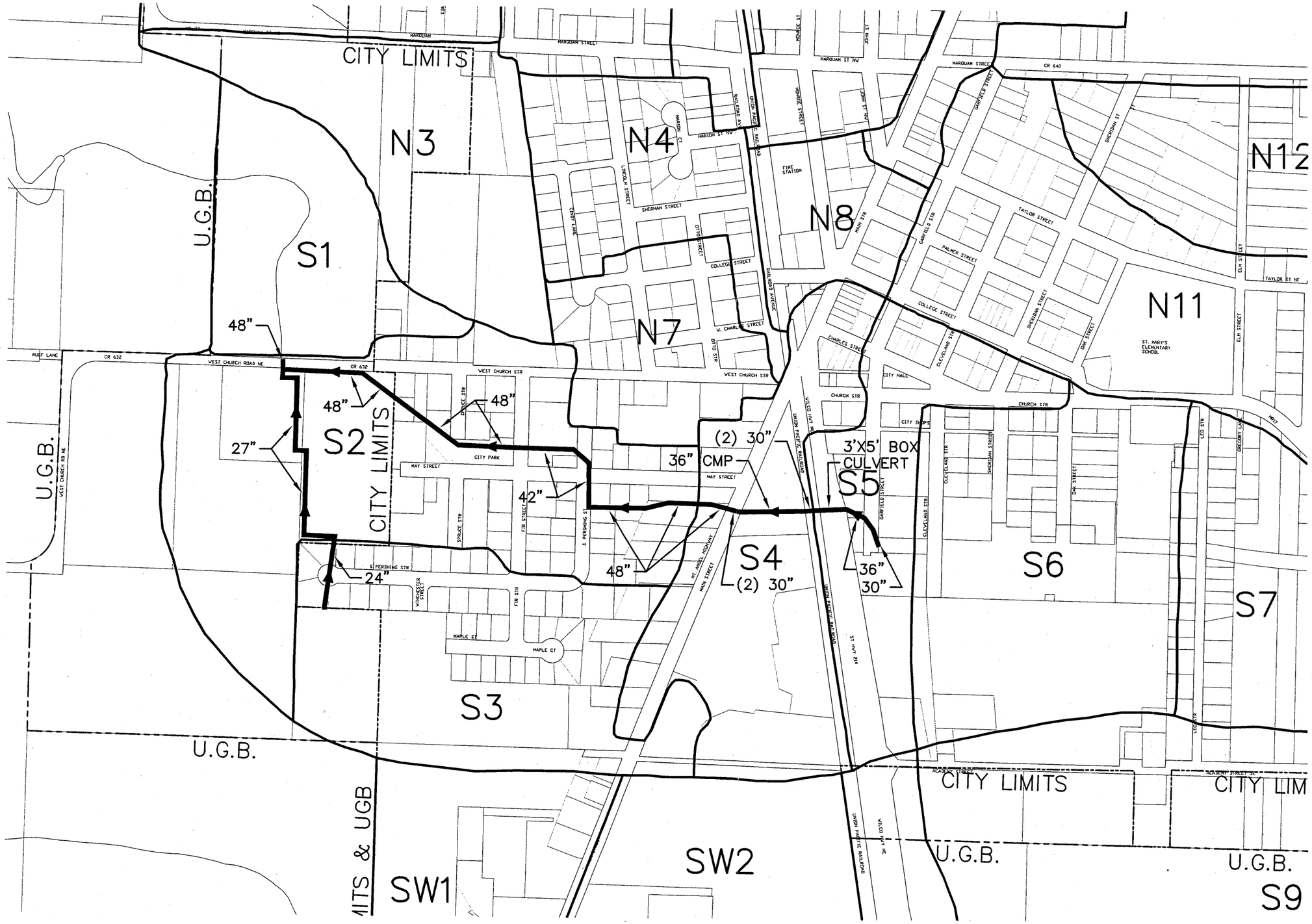
5.3 South Basin Evaluation

As discussed in Section 3, the South Basin is estimated to consist of approximately 316 acres, which have been divided into nine sub-basins for the purposes of this study. The South Basin is primarily served by a single trunk line that discharges at Church Street near the west UGB. A second, smaller trunk line serving sub-basin S3 to the south discharges at the same location.

The major storm drain trunk lines for the South Basin are shown in **Figure 5-6**. The primary trunk line is 48-inches in diameter at the Church Street discharge. The line continues as a 48-inch pipe as it extends east and southeast to just north of the intersection of Fir and May Streets. At this location it decreases to a 42-inch pipe that runs east then south to Pershing Street. In Pershing Street it increases back to 48-inches and turns back to the east towards Main Street. Continuing east, there are twin 30-inch pipes under Main Street then a 36-inch CMP between Main Street and the railroad tracks. There are twin 30-inch pipes under the railroad tracks followed by a 3'x5' box culvert under Highway 214. East of Highway 214 there is a short section of 36-inch pipe then a short section of 30-inch pipe. Upstream of the 30-inch pipe the drainage system is a series of open ditches combined with periodic field tiles, culverts, and short sections of pipe.

As noted above, the smaller, secondary, trunk line serves sub-basin S3, running directly south of the location where it connects to the primary trunk line at Church Street. The line is 27-inches in diameter between Church Street and the north side of the lots served by Pershing Street. At this location it decreases to a 24-inch pipe that crosses the Pershing Street development cul-de-sac. At the south side of this development flow is picked up from two sources. One is an open ditch from Main Street, while the other is a smaller pipe system that continues to the east.

Using the defined sub-basins and the storm drain network depicted in **Figure 5-6**, we analyzed the run-off for the South Basin using the Santa Barbara Urban Hydrograph (SBUH) computer model as implemented by Haested Methods in their PondPack software package. The results of this analysis is summarized and discussed in the following sections.



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CITY OF MT. ANGEL, OREGON
MT. ANGEL STORM DRAIN MASTER PLAN

SOUTH BASIN MAJOR STORM TRUNK LINES

FIGURE 5-6

SHEET 1 OF 1

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a. South Basin Existing Conditions

Table 5-7 presents a summary of the results of the SBUH calculations for the South Basin under existing conditions.

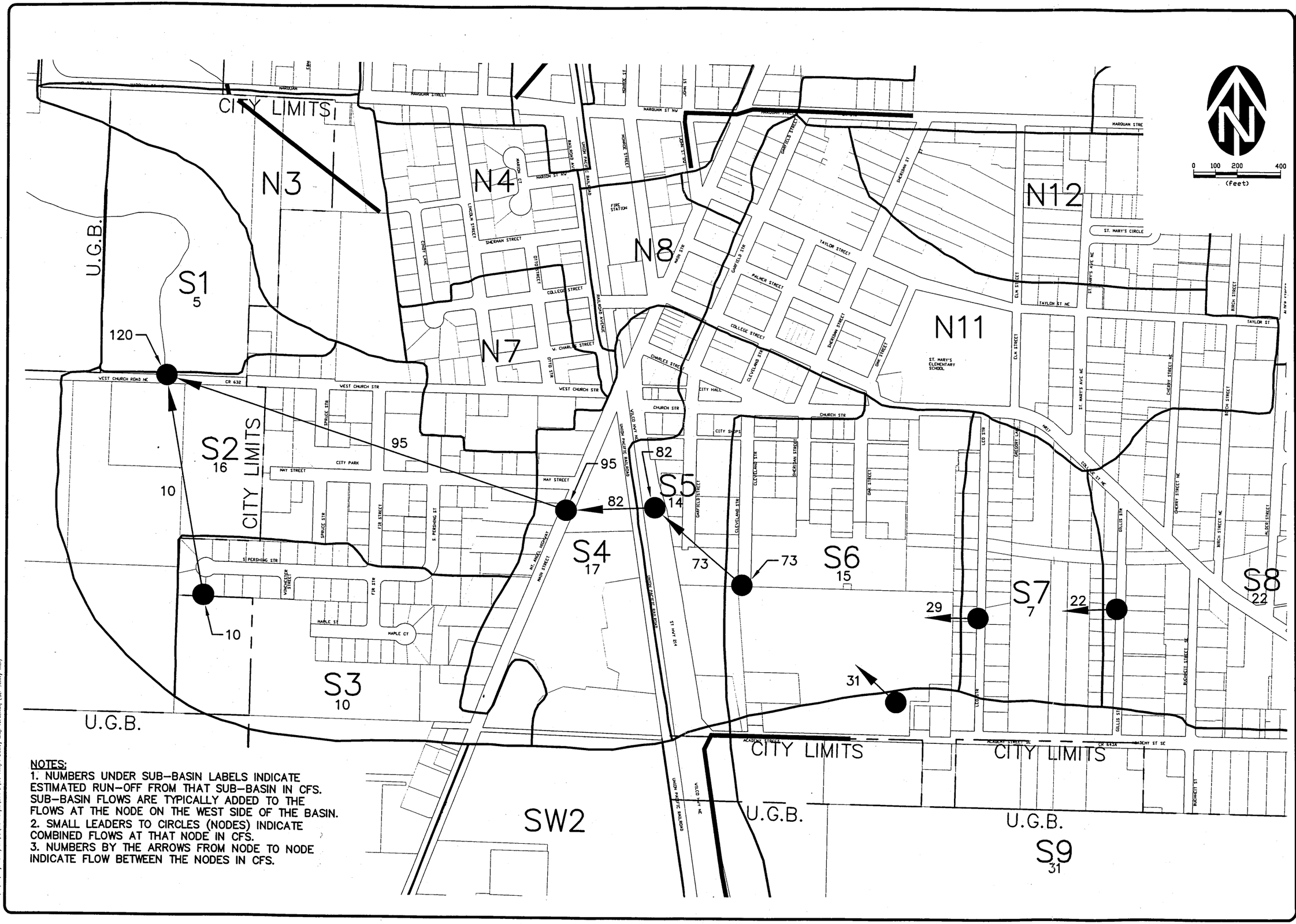
Table 5-7
SBUH Calculation Summary
South Basin – Existing Conditions

Sub-Basin	Size (acres)	CN	Tc (Hours)	Q (cfs)
S1	16	82	0.65	5
S2	44	85	0.73	16
S3	28	84	0.72	10
S4	25	91	0.23	17
S5	17	95	0.17	14
S6	33	87	0.57	15
S7	17	83	0.47	7
S8	46	85	0.37	22
S9	90	83	0.67	31

The calculated run-off (Q) from the table above is also shown on **Figure 5-7**, along with the flows as they were calculated through the storm drain pipe network. For a discussion of the composition of, and methodology behind, the figures and tables in this section, the reader may find it useful to review Section 5-2a North Basin Existing Conditions. The remainder of this section will be predominantly limited to a presentation of information without a reiteration of background information.

In the South Basin, the primary trunk line for the basin extends east only as far as Garfield Street. To the east of Garfield Street the drainage is an irregular mixture of culverts, short pipe segments, open channels, and farm field overflows. Therefore, in **Figure 5-7**, several additional nodes have been added to this figure indicating the combined flows at basin boundaries. However, given the irregular nature of the flow path, no flow arrows were drawn in these areas.

Figure 5-8 provides the direct comparison of estimated flow with estimated capacity and identifies pipe segments that are marginal or inadequate. This information is also summarized in **Tables 5-8** and **5-9**.



NOTES:
1. NUMBERS UNDER SUB-BASIN LABELS INDICATE ESTIMATED RUN-OFF FROM THAT SUB-BASIN IN CFS. SUB-BASIN FLOWS ARE TYPICALLY ADDED TO THE FLOWS AT THE NODE ON THE WEST SIDE OF THE BASIN.
2. SMALL LEADERS TO CIRCLES (NODES) INDICATE COMBINED FLOWS AT THAT NODE IN CFS.
3. NUMBERS BY THE ARROWS FROM NODE TO NODE INDICATE FLOW BETWEEN THE NODES IN CFS.

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MT. ANGEL STORM DRAIN MASTER PLAN

SOUTH BASIN
SBUH ESTIMATED FLOWS
EXISTING CONDITIONS

FIGURE 5-7

SHEET 1 OF 1

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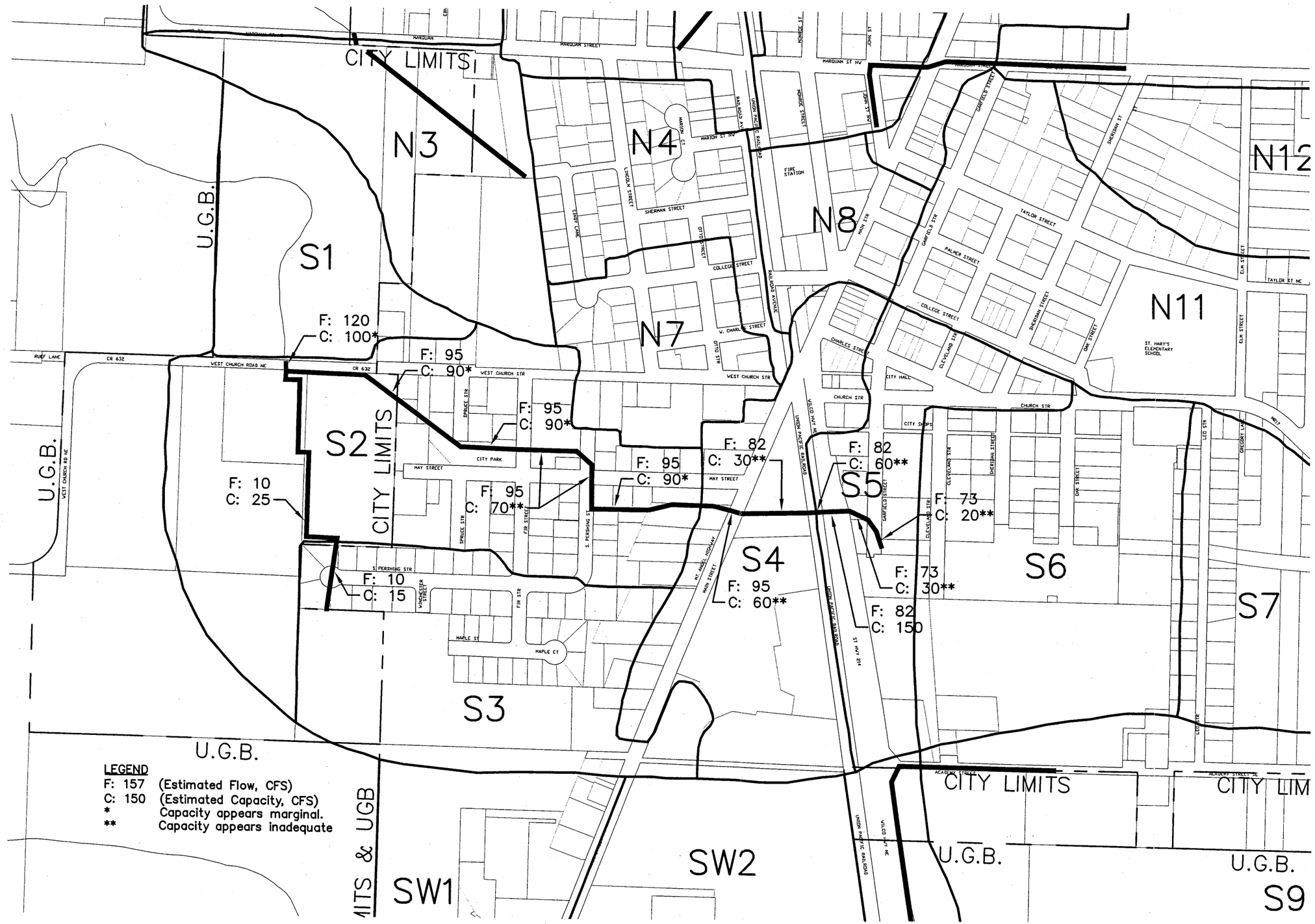

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SOUTH BASIN EXISTING FLOW & CAPACITY MAJOR TRUNK LINES

FIGURE 5-8

SHEET 1 OF 1

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Table 5-8 South Basin – Existing Conditions Marginal Pipe Segments (25-yr Storm)				
Pipe Location	Dia. (inches)	Est. Flow (cfs)	Est. Capacity (cfs)	Comments
Church St W of City Limits	48	120	100	Surcharges
Church St to Fir St	48	95	90	Surcharges
Pershing St to Main St	48	95	90	Surcharges

Table 5-9 South Basin – Existing Conditions Inadequate Pipe Segments (25-yr Storm)				
Pipe Location	Dia. (inches)	Est. Flow (cfs)	Est. Capacity (cfs)	Comments
Fir St to Pershing St	42	95	70	Additional capacity required
Main St	(2) 30	95	60	Additional capacity required
Main St to the Railroad	36 CMP	82	30	Additional capacity required
Railroad Crossing	(2) 30	82	60	Additional capacity required
Highway 214 to Garfield St	36	73	30	Additional capacity required
Garfield St	30	73	20	Additional capacity required

b. South Basin Future Conditions

Table 5-10 presents a summary of the results of the SBUH calculations for the South Basin under future, fully developed, conditions.

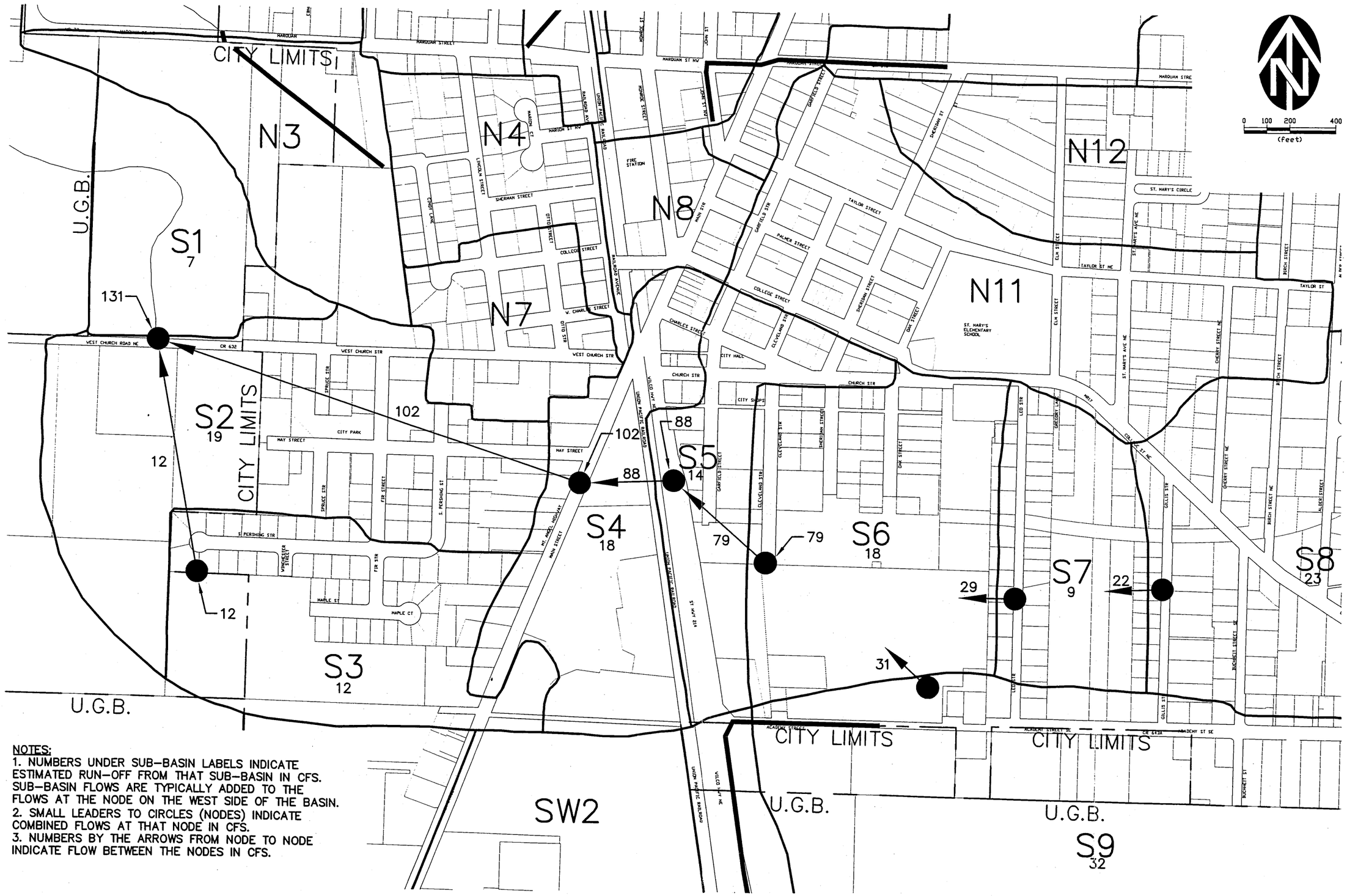
Table 5-10
SBUH Calculation Summary
South Basin – Future Conditions

Sub-Basin	Size (acres)	CN	Tc (Hours)	Q (cfs)	% Increase over exist.
S1	16	84	0.40	7	40%
S2	44	86	0.57	19	19%
S3	28	86	0.55	12	20%
S4	25	92	0.23	18	6%
S5	17	95	0.17	14	0%
S6	33	87	0.32	18	20%
S7	17	85	0.33	9	29%
S8	46	86	0.37	23	5%
S9	90	84	0.67	32	3%

The calculated run-off (Q) from the table above is also shown on **Figure 5-9**, along with the flows as they were calculated through the storm drain pipe network. For a discussion of the composition of, and methodology behind, the figures and tables in this section, the reader may find it useful to review Section 5-2a North Basin Existing Conditions. The remainder of this section will be predominantly limited to a presentation of information without a reiteration of background information.

The percent increase from existing conditions run-off to future conditions shown in **Table 5-10** varies significantly. When these combine, they result in trunk line flow increases in the range of 10%.

Figure 5-10 provides the direct comparison of estimated flow with estimated capacity and identifies pipe segments that are marginal or inadequate. This information is also summarized in **Tables 5-11** and **5-12**.



NOTES:
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2. SMALL LEADERS TO CIRCLES (NODES) INDICATE COMBINED FLOWS AT THAT NODE IN CFS.
3. NUMBERS BY THE ARROWS FROM NODE TO NODE INDICATE FLOW BETWEEN THE NODES IN CFS.

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SOUTH BASIN SBUH ESTIMATED FLOWS FUTURE CONDITIONS

FIGURE 5-9

SHEET 1 OF 1

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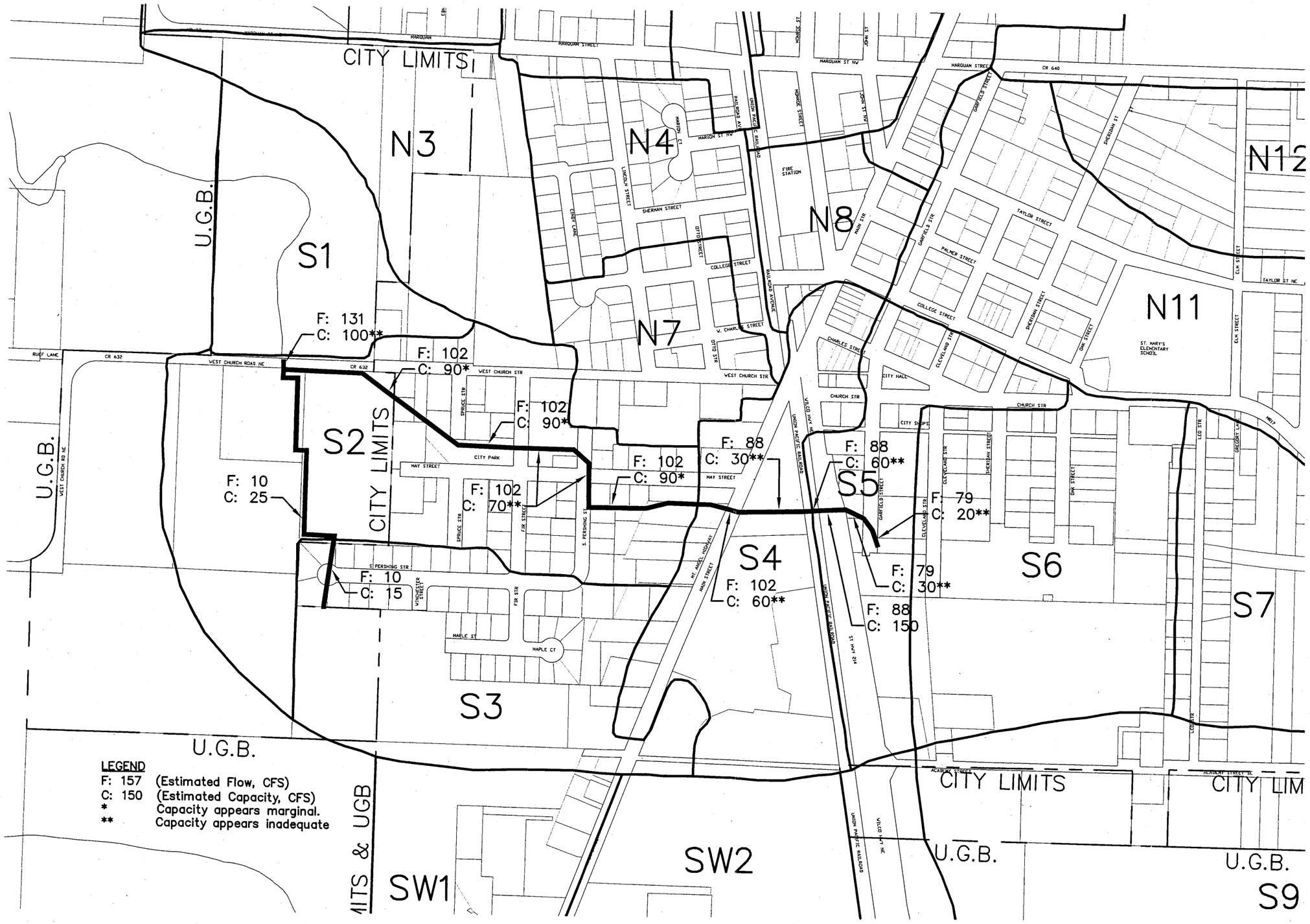

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SOUTH BASIN
FUTURE FLOW & CAPACITY
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FIGURE 5-10

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Table 5-11 South Basin – Future Conditions Marginal Pipe Segments (25-yr Storm)				
Pipe Location	Dia. (inches)	Est. Flow (cfs)	Est. Capacity (cfs)	Comments
Church St to Fir St	48	95	90	Surcharges
Pershing St to Main St	48	95	90	Surcharges

Table 5-12 South Basin – Future Conditions Inadequate Pipe Segments (25-yr Storm)				
Pipe Location	Dia. (inches)	Est. Flow (cfs)	Est. Capacity (cfs)	Comments
Church St W of City Limits	48	131	100	(+) Additional capacity required
Fir St to Pershing St	42	102	70	Additional capacity required
Main St	(2) 30	102	60	Additional capacity required
Main St to the Railroad	36 CMP	88	30	Additional capacity required
Railroad Crossing	(2) 30	88	60	Additional capacity required
Highway 214 to Garfield St	36	79	30	Additional capacity required
Garfield St	30	79	20	Additional capacity required
(+) Indicates new to this category compared to Existing Conditions.				

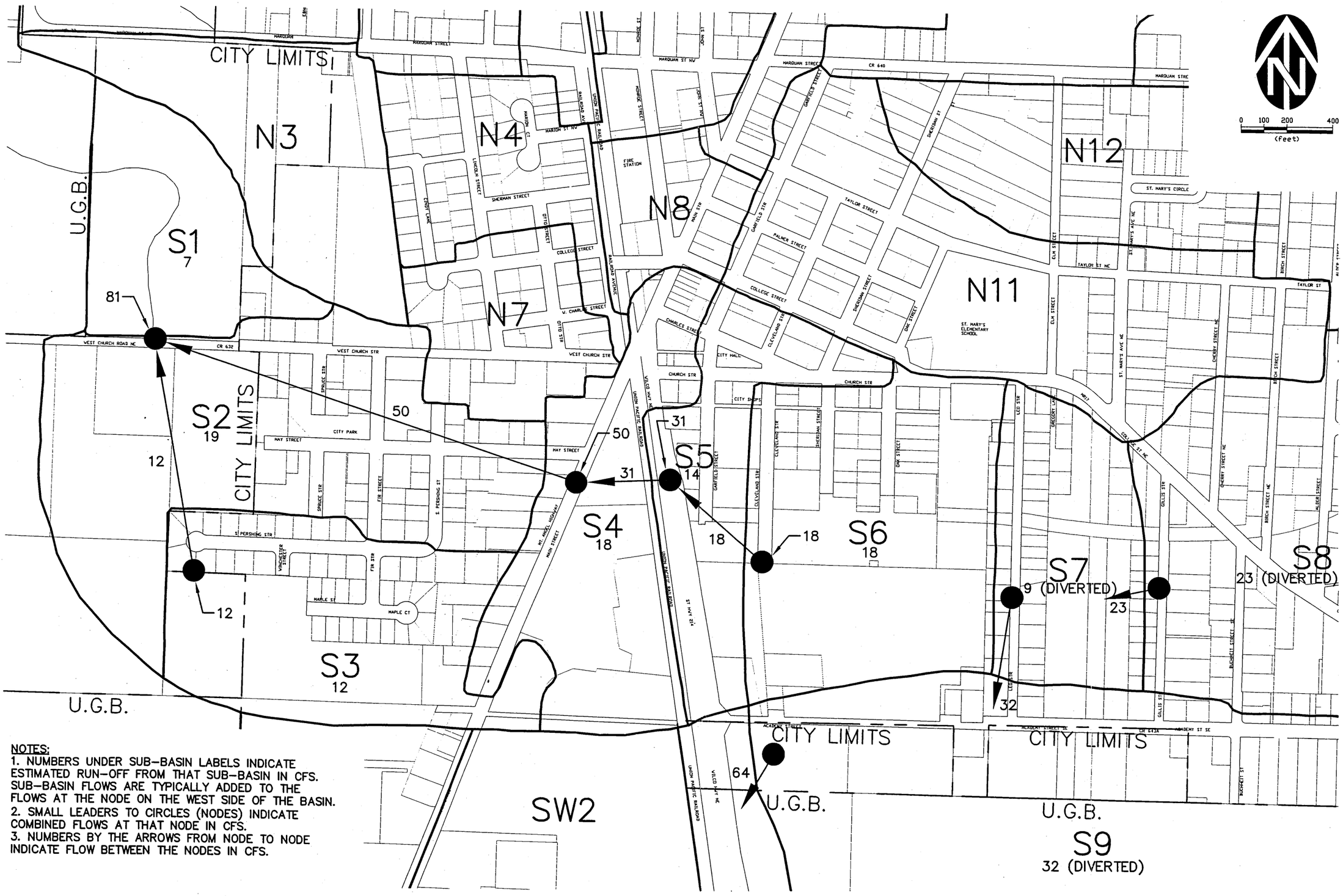
c. Modified South Basin Future Conditions

The evaluation presented above clearly shows that the primary major storm drain trunk line in the South Basin is inadequate to handle either current or future flows. Unless some substantial action is taken to reduce the demand on this line, the only alternatives for the City are to either continue to tolerate regular flooding in the South Basin, or to undertake an extremely expensive upgrade program that adds capacity for major segments of this line either by adding additional pipes, or removing and replacing the existing pipes with larger ones.

Fortunately for the City there is a comparatively easy and cost effective way to solve nearly all of the capacity problems in the South Basin. That solution is to divert sub-basins S7, S8, and S9 to Academy Street and route the flows around the City to the south, rather than allow them to enter the primary trunk line. Assuming future flows as presented by **Table 5-10** and **Figure 5-9**, the resultant flows in the South Basin would be as depicted in **Figures 5-11** and **5-12**. From these figures it becomes apparent that if sub-basins S7, S8, and S9 were diverted, all of the existing major trunk lines in the South Basin would have sufficient capacity to handle estimated flows.

d. South Basin Recommended Improvements

The recommendation for the South Basin is for the City to undertake the diversion of sub-basins S7, S8, and S9, and thereby relieve the major trunk line of a significant amount of flow. Such a project could be readily undertaken as Westech Engineering has the necessary survey information and has prepared a set of preliminary construction plans for this project which provide a good basis for evaluating project viability.



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2. SMALL LEADERS TO CIRCLES (NODES) INDICATE COMBINED FLOWS AT THAT NODE IN CFS.
3. NUMBERS BY THE ARROWS FROM NODE TO NODE INDICATE FLOW BETWEEN THE NODES IN CFS.

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MT. ANGEL STORM DRAIN MASTER PLAN

MODIFIED SOUTH BASIN SBUH ESTIMATED FLOWS FUTURE CONDITIONS

FIGURE 5-11

SHEET 1 OF 1

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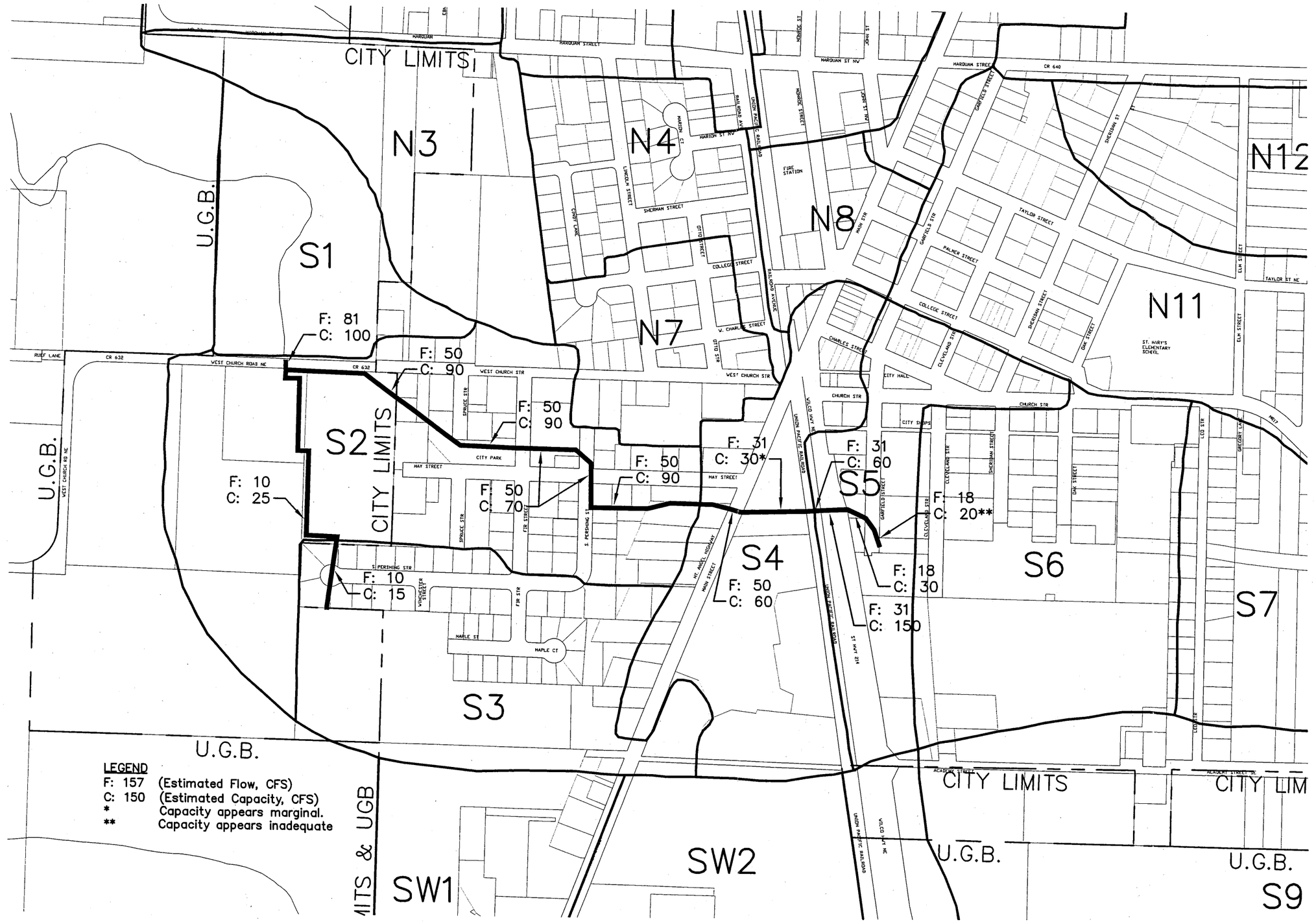

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MODIFIED SOUTH BASIN FUTURE FLOW & CAPACITY MAJOR TRUNK LINES

FIGURE 5-12

SHEET 1 OF 1

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5.4 Stormwater Drainage System Capital Improvement Plan (CIP) Elements

This section is provided to compile, prioritize, and provide cost estimates for the recommended improvements for both the North Basin and the South Basin. These improvements are shown on **Figure 5-13**. The priorities assigned on this figure are based on the following definitions.

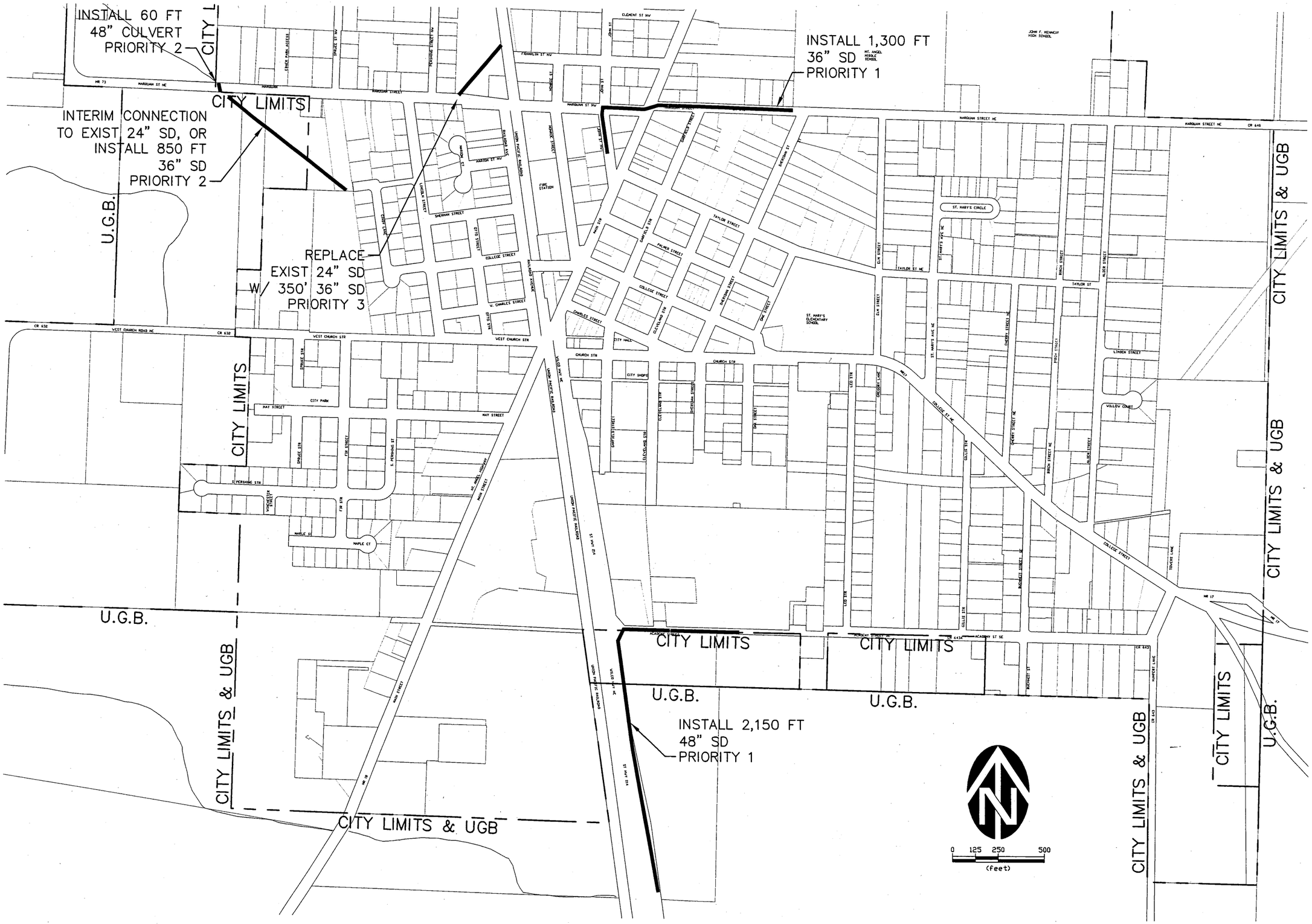
- **Priority 1** (Near Term Improvements) - These are those projects representing existing system deficiencies (currently needed to meet existing and near future projected stormwater runoff flows) or problem areas needing immediate attention. It is recommended that Priority 1 improvements be accomplished as soon as practical considering financing, construction time requirements and timing associated with other related projects.

- **Priority 2** (Vital Future Improvements) - These are improvements which will be needed in the future to meet projected development conditions and design flows. Although not necessary at this time, they should be considered as improvement projects which will be upgraded to Priority 1 in the future.

- **Priority 3** (Long Term Improvements/Possible Future Need) - These improvements are needed to improve system reliability and convey future design flows if land develops to zone intensities. While important, they are not considered to be critical at the present time, or are deemed less desirable due to cost/benefit or impact standpoint. These improvements should be incorporated into street or other utility improvement projects which may allow for concurrent construction.

The estimated cost for each project is listed in **Table 5-13**. The construction costs are based on the size of pipe required, and whether or not the pipe is in a paved area and therefore requires crushed rock backfill and paved trench surface restoration. The construction costs are intended to represent all construction costs, including mobilization, bonds, permits, insurance and all of the various miscellaneous costs associated with each project. In addition to construction costs, a 10% contingency, 16% for engineering services, and 10% for legal and project administration are listed to provide a comprehensive estimate of all costs associated with the project. These estimates are rough planning level estimates and not based on detailed design. Therefore, they should be considered preliminary and subject to change.

The two projects identified as Priority 1 would eliminate significant problem areas for both existing and future conditions without reconstructing major elements of the existing storm drain trunk systems. While they are both expensive projects to construct, we believe the approach recommended is the most cost effective, providing the greatest benefits to the system at the lowest cost and with the least disruption to the community compared to the alternative of increasing the capacity of the system along the current routes.



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DATE: MAR '02

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CITY OF MT. ANGEL, OREGON

MT. ANGEL STORM DRAIN MASTER PLAN

RECOMMENDED CAPITAL IMPROVEMENT PLAN (CIP) PROJECTS

FIGURE 5-13

SHEET 1 OF 1

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TABLE 5-13

Capital Improvement Project (CIP) Estimated Costs*

PROJECT	Priority	Pipe Size (in)	Paved or Unpaved	Length (ft)	Cost/ft ($)	Manholes	Cost/Ea ($)	Inlets	Cost/Ea ($)	Construction Cost ($)	Contingency (10%)	Engineering (16%)	Legal & Admin (10%)	Project Total ($)
NORTH BASIN														
Marquam St Culvert	2	48	Paved	60	$250					$15,000	$1,500	$2,400	$1,500	$20,400
36-inch Pipe by 48-inch pipe S. of Marquam St	2	36	Unpaved	850	$130	2	$10,000	2	$1,000	$132,500	$13,250	$21,200	$13,250	$180,200
36-inch pipe, Marquam St to RR	3	36	Unpaved	350	$130	1	$7,500	2	$1,000	$55,000	$5,500	$8,800	$5,500	$74,800
36-inch pipe, John St to Middle School	1	36	Paved	1300	$160	6	$10,000	12	$1,000	$280,000	$28,000	$44,800	$28,000	$380,800
SOUTH BASIN														
48-inch pipe, Academy St and Wilco Highway	1	48	Unpaved	2100	$180	6	$7,500	2	$1,000	$425,000	$42,500	$68,000	$42,500	$578,000

*Note: These estimates are planning level cost estimates and not based on actual designs. They should be considered as preliminary and subject to change.

5.5 Minor Basins

In this study we identified and designated three minor basins; Northwest, Southwest, and East. These basins are comparatively small and have minimal existing storm drainage infrastructure. They are included in this report to provide a baseline for identifying the appropriate storm drain infrastructure as these basins develop. However, due to the wide range of development possibilities a detailed analysis of proposed storm drainage should be part of the review of any substantial development proposal prior to its approval.

a. Northwest Basin

The Northwest Basin consists of approximately 117 acres, much of which is currently outside the UGB and largely undeveloped. The upper end of the basin contains industrial land used by the Mt. Angel Beverage Company. Flow from this area passes under the railroad tracks and across a property in the UGB designated for low density residential. This route is served to a minor extent by a private storm line of unknown size or exact location. Any excess flow sheets across the fields.

The estimated flows for the Northwest Basin are approximately 30 cfs under existing conditions, and 38 cfs under future conditions. Any proposed development in the Northwest Basin should be carefully analyzed to ensure it provides for proper management of storm drainage. If the development starts at the lower end of the basin, care must be taken to size the system to handle all anticipated flows from upstream, and provide a point of connection for future development. Development occurring in the middle or upper end of the basin may present even greater challenges, as it should be required to show how it will handle its storm drainage so as to not impact the downstream properties.

b. Southwest Basin

The Southwest Basin may actually be best viewed as two separate basins. The two sub-basins, SW1 and SW2, are geographically and topographically arranged that it is unlikely that flow from one sub-basin would be routed through the other. In both cases the southern boundary is near Walker Ditch, and it is likely that all flow would routed directly to this drainageway.

The estimated flows for SW1 are 6 cfs under current conditions, and 10 cfs under future conditions. For sub-basin SW2 the estimates are for 12 cfs under both current and future conditions.

c. East Basin

The East Basin is primarily within the current City Limits, and is roughly half developed, with most of the development existing at the upper end of the basin. The estimated flows for the East Basin are 17 cfs under current conditions and 21 cfs for future conditions.

The stormwater runoff from the existing development passes through an undersized storm drain line to Marquam Street. Any proposed development between the existing development and Marquam Street should be reviewed to ensure it properly addresses the need to provide stormwater improvements with capacity on the order of those listed above.

5.6 Stormwater Detention

The primary purpose of stormwater detention is to mitigate the impacts of development on downstream drainage systems. As property develops, the increased impervious area allows the stormwater to travel more quickly resulting in a greater concentration of water in a shorter time period. By capturing the runoff from developed areas in a detention facility, the opportunity is created to release the runoff at a controlled rate, typically related to the flow estimated in the undeveloped condition.

While stormwater detention has potential benefits when properly implemented, it is not without costs. One potential cost is loss of developable land. Some of the simplest and least expensive detention facilities are ponds created on the site. A second method of creating detention capacity is to do so underground in vaults or pipes. While this method is more expensive to construct, it typically allows the development of a greater percentage of the site. Whether constructed above or below ground, there is a cost to the development to provide a detention facility. Once in existence, these facilities become a long-term maintenance responsibility, which incurs additional cost.

The following is a hypothetical example of the benefits and costs associated with stormwater detention. The case involves a two-acre site on gently sloping ground (1-2%) developing from residential to commercial property. The existing CN number is 84, and the estimated time of concentration is 25 minutes (0.42 hours). The future CN is 94, and the estimated time of concentration is 12 minutes (0.20 hours). The runoff from the various conditions for this site are presented in **Table 5-14**. The hydrograph for each condition is shown in **Figure 5-14**.

Table 5-14
Site Run-off Comparison (cfs)

	5-yr Storm	25-yr Storm
Undeveloped	0.5	0.9
Developed	1.1	1.6

The City of Mt. Angel's current detention standard, outlined in the Public Works Design Standards, requires development to control run-off to that generated by a 5-year storm under existing conditions. The detention facility must then be sized to contain the difference between a 25-year storm post-development and the 5-year storm under existing conditions. To show the impact of this requirement, calculations were performed assuming a pond 50 feet long and 50-feet wide. During the course of the simulated 25-year storm event, this imaginary pond filled to a depth of 1.9 feet, and generated the controlled release curve shown in **Figure 5-15**. Under this scenario a detention pond with a total volume of 4,750 cubic feet (50x50x1.9) would be required to provide the required amount of detention. If underground storage was desired, it would require more than 750 feet of 4 foot diameter pipe to generate the necessary volume.

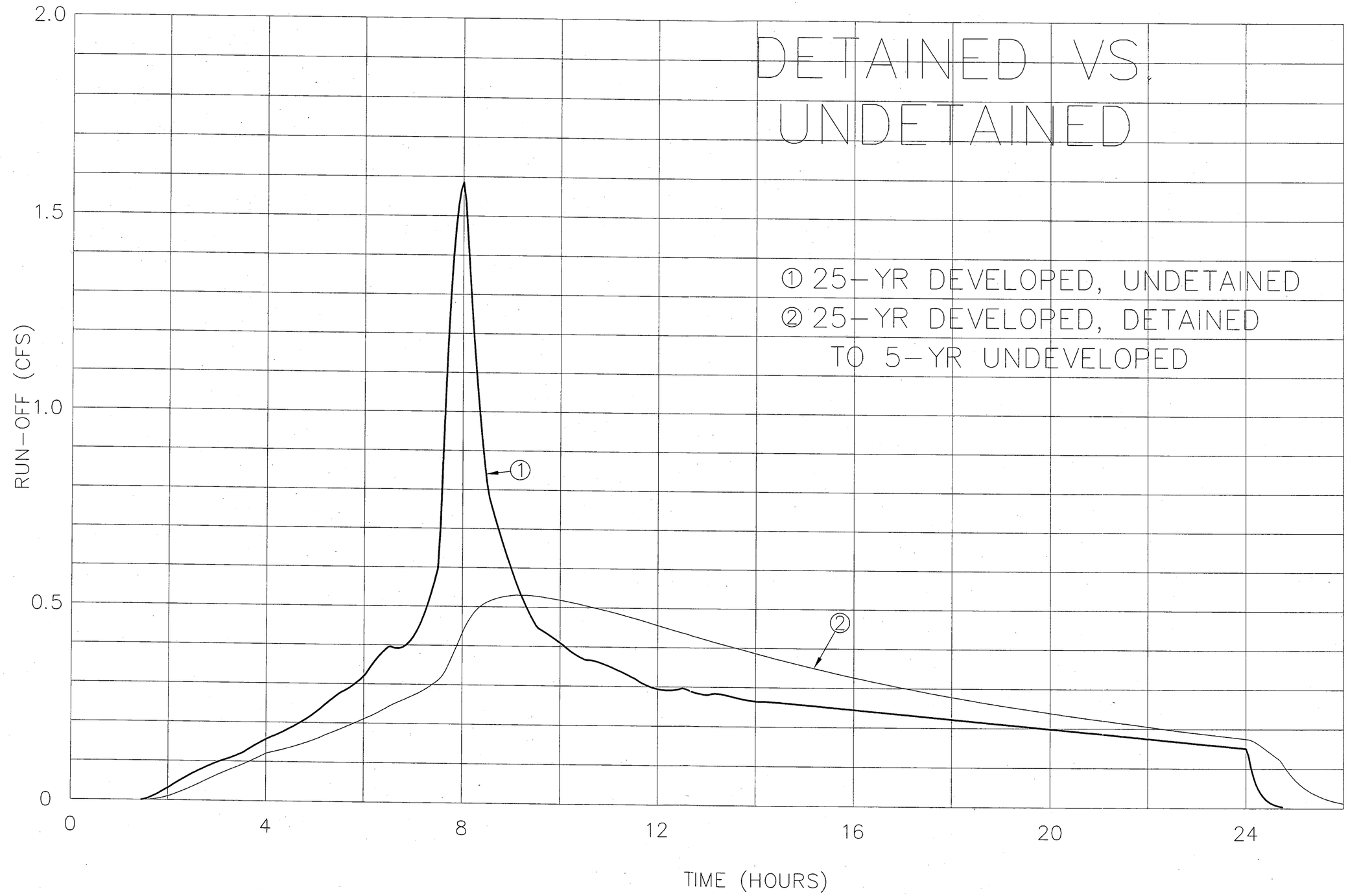
There are alternate methods of calculating the required detention volume. The method shown here is a comparatively conservative approach. Other methods may result in noticeably lower required storage volumes. However, even at half the volume, the impact to the site and/or the project cost are not inconsequential.

Having worked through that example to show the impacts to development projects, it is now necessary to consider the benefits to the public system. For Mt. Angel this analysis is particularly important since, as already discussed at length in previous sections, the City has numerous segments of its storm drain trunk lines that appear to be at or near capacity, even under existing conditions.

The potential benefits of detention may arise from two possible situations. The first relates to the local system immediately downstream of the site. Based on **Table 5-14**, the hypothetical development discussed above would see runoff roughly double in the change from undeveloped to developed conditions. In real terms, even in a 5-year storm this would result in an increase in run-off of over half a cubic foot per second. If the pipe adjacent to the site is a 12-inch at typical grades of 1% or less, from **Table 4-3** we can see that it would have a capacity in the range of 3-4 cfs. Thus, the 0.5 cfs increase takes roughly 15% of the pipe capacity just to serve the increased development from this one site.

The other potential benefit of detention relates to controlling the demand placed on the trunk lines. In considering this issue, it is useful to look back to **Table 4-1**. This table is based on a time of concentration of one hour, which is more representative of the system-wide behavior experienced by the major trunk lines. From this table we note that development from residential to commercial results in an increase of approximately 50% (3.01 cfs as residential, 4.69 cfs as commercial). Thus, while the impact is not as dramatic as it is immediately adjacent to the site, the cumulative effect of development could be significant, depending on the remaining undeveloped, or under-developed percentage of the basin.

In looking at **Tables 5-4** and **5-10**, we noted that the overall increase from the current state of development to full development, was only on the order of 10-20%. However, given the near or above capacity of many of the trunk lines. This increase could prove problematic.



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CITY OF MT. ANGEL, OREGON

MT. ANGEL STORM DRAIN MASTER PLAN

SBUH HYPOTHETICAL SITE
DETENTION RUN-OFF

FIGURE 5-15

SHEET 1 OF 1

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Therefore, for both the interest of the local system adjacent to potential development sites, and the major system trunk lines, we believe it makes good sense for the City of Mt. Angel to employ some sort of detention requirement. The detention requirement currently adopted as part of the City's Public Works Design Standards, and briefly discussed above, limiting run-off to the 5-year, existing conditions value, and requiring detention for the difference between the pre-developed 5-year and post-developed 25-year events is a fairly common standard. We continue to believe that this standard is appropriate for the City of Mt. Angel.

Finally, for completeness it is necessary to note that some other communities employ a concept known as regional detention to control stormwater run-off. Rather than requiring each development to provide detention, a site is selected that can provide detention for several sites, or even whole sections of the community. Regional detention requires a site along the main drainageway that has the capacity to hold large volumes of water that are released at a comparatively slow rate. In effect, regional detention ponds are like small reservoirs. Since there are no sites along either of the main trunk lines that appear to have the potential to serve as regional detention sites, we do not envision regional detention working effectively in Mt. Angel.

5.7 Local Problem Areas.

In the course of performing this study, several locations around the City were noted as having persistent problems that the City would like addressed. The following is a brief discussion of what was observed in each area, and a possible remedy.

The existing line in Marquam Street west of Garfield Street is undersized. The west end of this line is an 18-inch pipe that serves both sub-basin N13 and sub-basin N14. While this pipe segment has the capacity to handle flows in the range of 15-20 cfs, the projected flows are 34 cfs for existing conditions and 40 cfs for future conditions. If constructed, the recommended 36-inch pipe from John Street to the west side of the middle school would correct this problem.

Continuing east on Marquam Street the line decreases to 12-inches, then to 10-inches. Lines of this size can be expected to carry 2 –4 cfs. This line serves all of sub-basin N14, which is estimated to generate 13 cfs of run-off. It is our understanding that significant problems are not currently being experienced in this area. This is probably due to the relatively low density residential development in sub-basin N14 at this time. If this sub-basin experiences infill development, additional capacity in the east end of Marquam Street may become necessary.

City Staff noted a concern regarding flooding problems in the core downtown area around City Hall, on Garfield, Church, and Charles Streets. The problem in this area is that the storm drain pipes in this area are small, only 6-8 inches in diameter. While these pipes are adequate for most conditions, including large storms as long as they are spread out over a period of time, such pipes are insufficient to handle the runoff from intense rainfall, such as a heavy downpour from a thunderstorm. In such cases, a temporary backup will occur, that will then disappear as the rainfall intensity decreases. Given the infrequent, short duration nature of these problems, we do not recommend the City plan on upgrading these pipes until major street reconstruction is necessary in this area.

CITY OF MT. ANGEL
Storm Drainage System Master Plan

Section 6

DESIGN STANDARDS & MANAGEMENT PRACTICES

SECTION 6
DESIGN STANDARDS & MANAGEMENT PRACTICES

6.1 General

This section provides information and recommendations to the City regarding design standards and management practices for the City's storm drainage system. The development and adoption of design standards will aid the City in providing direction to developers seeking to extend or improve the drainage system to serve new developments. Another concern of the City's is the operation and maintenance of existing storm drainage facilities. The second part of this section provides suggestions intended to help the City develop procedures and standards for the management of storm drainage facilities.

6.2 Storm Drainage System Design Standards

The City has adopted Public Works Design Standards (PWDS) that are intended to provide guidelines for the design of public facilities that will provide an adequate service level for the present development as well as for future development. The PWDS cannot provide for all situations. They are intended to assist but not to substitute for competent work by design professionals.

These standards were drafted with the intent that they:

- Be consistent with current City Ordinances;
- Provide design guidance criteria to the private sector for the design of public improvements within the City of Mt. Angel;
- Be of adequate design to safely manage all volumes of water generated upstream and on the site to an approved point of disposal;
- Provide points of disposal for stormwater generated by future upstream developments;
- Prevent the uncontrolled or irresponsible discharge of stormwater onto adjoining public or private property;
- Prevent the capacity of downstream channels and storm drainage facilities from being exceeded;
- Have sufficient structural strength to resist erosion and all external loads which may be imposed;
- Maximize the use of the City's natural drainage system;

- Be designed in a manner to allow economical future maintenance; and

- Require the use of design and materials to provide a system with a minimum practical design life of not less than 50 years.

For specific information regarding current City requirements, the Public Works Design Standards should be obtained from the City of Mt. Angel.

6.3 Storm Drainage Quality Standards

The City of Mt. Angel's combination of circumstances currently lends itself to limited need for specific stormwater quality standards. In communities where stormwater quality requirements are in use, the primary objective is to reduce contaminants from entering biologically active waterways. Since the Mt. Angel is primarily a residential community somewhat removed from the nearest stream, and served almost exclusively by a piped drainage system, the benefits of water quality systems is likely to be limited.

Two of the most common methods of reducing stormwater contaminants are grassed swales or filter systems in concrete vaults. These systems settle out large particulates, and use biological media (grasses or organic filter media) to remove organic nutrients. The ditches on the west side of the City where the major trunk lines discharge naturally provide this function for the City's stormwater before it makes its way to the Pudding River.

Should the City wish to consider stormwater quality requirements, it will be important to note the limitation the local topography places on the use of many systems, at least in large portions of the City. The two main types of stormwater quality systems listed above, swales and filtration structures, require hydraulic gradient (elevation difference) to implement. One set of standards commonly used for swales (Clean Water Services, formerly the Unified Sewerage Agency, in the Portland Metro area) requires a minimum channel slope of 1.5%. Filtration systems also require an elevation difference to create water pressure to force the water through the filters. Given the flat terrain within the City, it is very likely that construction of either of these types of systems would be physically impossible.

Given these factors, we believe the City is best served by providing community education and awareness programs to help local citizens understand the importance of keeping contaminants out of the storm drainage systems. These programs typically focus on issues like over use of pesticides and fertilizers, and prevention of using the ditches for disposal of yard debris or trash.

Finally, with the amount of available industrial and commercial land within the City, the City should provide for the ability to address storm drainage water quality on a case-by-case basis at the time of approval for new industrial or commercial activities. Most of the current activity in the current commercial and industrial zones does not pose a significant threat to stormwater quality. However, future proposals may present activities that may have greater risk potential, and the City may wish to have language in their ordinances that allows them to place specific

requirements on specific developments depending on the nature of the activity and potential risk to the stormwater system.

6.4 Storm Drainage System Construction Standards

The City does not presently have any detailed construction standards for stormwater system improvements under City jurisdiction. Until the City develops Public Works Construction Standards (PWCS) specific to the City's infrastructure, it is recommended that the City adopt the Standard Specifications for Public Works Construction as prepared by the Oregon Chapter of the American Public Works Association (APWA).

These PWCS will provide a uniform set of standards for use by contractors during the construction of stormwater improvements. The PWCS cannot provide for all situations. They are intended to assist but not to substitute for competent work by experienced professional contractors.

6.5 Storm System Management Practices

In order to ensure that the City's storm drainage system continues to function effectively, and to maintain the full capacity of the existing storm drainage system, a regular program of maintenance is recommended.

A successful maintenance program should include the following objectives:

Provide for public safety
Reduce potential of property damage by obstructed facilities
Evaluate and upgrade maintenance priorities
Reduce impact on City's resources
Maintain capacity and integrity of storm drainage system
Identify future maintenance needs
Add projects to the stormwater CIP as appropriate
Reduce nuisance water on public streets

The most important objectives of the maintenance program should be to provide for public safety and reduce unplanned storm water flow or flooding on private and public property. It also allows access to public roads to be maintained during storm events for emergency and private vehicles.

Priorities should be established and re-evaluated yearly to ensure that resources are allocated reasonably and fairly. In this manner, limited City resources are not used for resolving minor storm drainage systems when major facilities are in need of repair or improvement. As repairs are made and yearly evaluations are performed, new problem areas and other maintenance requirements can be identified and prioritized. Another benefit is that City residents visibly see that their concerns are being addressed by the City.

For purposes of evaluating the storm drainage maintenance requirements for the City, typical maintenance requirements were developed for each type of structure in the system along with typical maintenance requirements for different conditions. **Table 6-1** outlines typical maintenance requirements for pipes and culverts, while **Table 6-2** outlines those for catch basins.

Table 6-1
Recommended Maintenance Standards For Pipes & Culverts

Maintenance Category	Condition Requiring Maintenance	Recommended Maintenance
Sediment and debris	Accumulated sediment exceeds 20% of the pipe diameter	Clean pipe of all sediment and debris
Vegetation	Vegetation that reduces free movement of water through pipes	Remove all vegetation so water flows freely through pipes
Damaged pipe	Protective coating is damaged and rust causing more than 50% of deterioration to any part of pipe	Repair or replace pipe
	Any dent that decreases the end area of pipe by more than 20%	Repair or replace pipe
Debris barrier plugged	Trash or debris plugging more than 20% of the barrier openings	Clear barrier of all debris
Damaged/missing bars	Bars are missing or entire barrier missing	Replace bars per design
	Bars are missing or entire barrier missing	Replace bars per design
	Bars are loose and rust is causing 50% deterioration to any part of barrier	Repair or replace barrier to design

Table 6-2 Recommended Maintenance Standards For Catch Basins		
Maintenance Category	Condition Requiring Maintenance	Recommended Maintenance
Trash and debris (including sediment)	Trash or debris of more than 1/2 cu ft located in front of the catch basin opening or blocking capacity of basin by >10 percent	Clean trash or debris from in front of catch basin opening
	Sediment, trash or debris in the basin greater than 1/3 to 1/2 the depth of the sump	Remove sediment, trash and debris from catch basin
	Sediment, trash or debris in any inlet or outlet pipe blocking more than 1/3 the diameter	Remove sediment, trash and debris from catch basin
Structural damage or deterioration of curb or frame	Deterioration of curb at inlet location	Replace curb across inlet location
	Damage to diamond plate covers in sidewalk	Repair or replace cover
Cracks in basin walls or bottom	Cracks wider than ½ inch or longer than 3 ft, any evidence of soil particles entering catch basin through cracks, or structure is unsound	Basin repaired or replaced
	Cracks wider than ½ in and longer than 1 ft at the joint of any pipe or any evidence of soil particles entering catch basin through crack	Repair/grout cracks
Settlement/misalignment	Basin has settled more than 1 in or has rotated more than 2 in out of alignment	Basin reset or replaced
Fire or chemical hazard	Chemicals such as natural gas, oil, and gasoline in storm drain system	Remove flammable or hazardous chemicals
Vegetation	Vegetation growing across and blocking more than 10 percent of basin	Remove vegetation blocking basin
	Vegetation growing in inlet/outlet or roots at pipe joints	Remove vegetation and roots

Based on these typical maintenance requirements, a sample maintenance budget worksheet was developed using assumed production rates and unit costs for the various maintenance functions. The level of service and assumed unit costs for the various maintenance functions are presented in **Table 6-3**. This should not be regarded as a final budget number, but is intended only to provide a sample for use in developing a realistic budget as the City implements funding programs for storm system maintenance. In summary, the maintenance budget should allow for cleaning of all catch basins bi-annually, all pipes on a 5-year cycle, and other maintenance, repair, replacement, and system inventory requirements as shown.

To develop a storm system maintenance program for the City, the following recommendations should be implemented:

- Once funding mechanisms are in place, allocate an amount determined by Public Works as the Storm System Maintenance Budget for repairs of "minor" storm drainage facilities. **Table 6-3** can be used a starting point for developing this budget.

- Implement routine inspections of system elements (i.e., catch basins, culverts, etc.) to observe debris accumulation and structural conditions, and to evaluate the required procedures, materials, equipment, personnel, urgency, time, and cost for maintenance activities.

- Develop a storm drainage database to inventory system elements, record maintenance actions and inspection logs, and monitor public concerns (complaints of local problem areas).

- Regularly evaluate database to determine maintenance patterns and refine manpower and budgetary requirements.

- Obtain access easements to existing public facilities from private owners.

- Inspect and evaluate detention ponds (schedule maintenance when capacity is reduced by one-third due to sedimentation).

- Develop a program to require maintenance for private water quality facilities.

- Provide an emergency fund to deal with catastrophic events effecting storm drainage facilities.

Table 6-3
Sample Maintenance Budget Worksheet

Item No.	Category	Number to be Maintained	Frequency (times/yr)	Standard #/Length per day	Crew Size	Total days per year	Labor Cost/ Crew day	Equipment Cost (% Labor)	Preliminary Maintenance Costs				Percent of Total Budget
									Labor Cost	Material Cost	Equipment Cost	Total Cost	
1	Clean Catch Basins	70	0.5	15	1	2.3	$200	50%	$467	$0	$233	$700	2%
2	Clean Major Culverts/Pipe Inlets	12	1	15	1	0.8	$200	50%	$160	$0	$80	$240	1%
3	Clean Storm Lines	58,000	0.2	1000	2	23.2	$200	100%	$4,640	$0	$4,640	$9,280	31%
4	Clean/Regrade Major Ditches	500	0.5	1000	2	0.5	$200	100%	$100	$0	$100	$200	1%
5	Clean/Regrade Roadside Ditches	12,000	0.25	2000	1	1.5	$200	200%	$300	$0	$600	$900	3%
6	Repair Major Culverts	6	0.2	1	2	2.4	$200	40%	$480	$0	$192	$672	2%
7	Repair Storm Lines	400	1	50	2	16.0	$200	100%	$3,200	$0	$3,200	$6,400	22%
8	Repair/replace Catch Basins	360	0.05	2	2	18.0	$200	50%	$3,600	$0	$1,800	$5,400	18%
9	Complaint Response	12	1	1	1	12.0	$200	0%	$2,400	$0	$0	$2,400	8%
10	System Inventory Reconnaissance	1	6	1	1	6.0	$200	0%	$1,200	$0	$0	$1,200	4%
													93%
				Total crew days/yr		82.7							
				Sub-total: All Maintenance Categories					$16,547	$0	$10,846	$27,392	
							Administration & Overhead @ 8%					$2,191	
							Grand Total					$29,583	

6.6 Legal/Liability Issues

This section presents a general background on drainage-related legal/liability issues and should not be used in lieu of advice from the City's legal counsel. Therefore, the following items present a basis for further investigation by the City into potential liabilities with storm drainage master planning and implementation of improvements. Historically, the basis for stormwater litigation has been a tort action, as follows:

- In the State of Oregon, the civil law doctrine of drainage applies. Under this doctrine, adjoining landowners are entitled to have the normal course of natural drainage maintained. The lower owner must accept water which naturally comes to his land from above, but he is entitled not to have the normal drainage changed or substantially increased. The lower landowner may not obstruct the runoff from the upper land, if the upper landowner is properly discharging the water (Reference 1).

- A municipality undertaking a public drainage improvement is treated like a private party (Harbison v. City of Hillsboro) and is liable for damage resulting from negligence or an omission of duty (Reference 2).

- Municipalities are generally under no legal duty to construct drainage improvements unless public improvements require drainage facilities (Denver v. Mason) (Reference 3).

- Municipalities are not liable for damages due to overflow of its drainage system in cases of extraordinary/unforeseeable rains or floods. (McQuillan) (Reference 4).

- Municipalities will likely be liable in cases where they take responsibility for collection of surface waters which are then released onto private property which has not historically received runoff, where dams/diversions cause an overflow onto another's land, or where there is failure to exercise reasonable care in the maintenance and repair of drainage improvements (Reference 4).

6.7 Funding Issues

This section describes the range of alternative funding sources that municipalities have used in implementing drainage improvements.

a. State/Federal Grants and Loans

Various grant/loan programs are available at both the federal and state level. However, no single grant/loan program is available on a consistent, on-going basis for funding of local stormwater management. With communities competing on both a state-wide and even nation-wide basis, and with constraints on how grant/loan money is to be used, these sources can only serve to supplement an existing local funding program for stormwater management.

b. Debt Financing

General obligation bonds and revenue bonds are two commonly used forms of debt financing for public infrastructure improvements. General obligation bonds, primarily used for major capital improvements, are subject to voter approval and are backed by the full credit of the government issuing them. Revenue bonds, on the other hand, may be sold and secured only by those specific revenue sources which are earmarked for their payment.

c. System Development Charges

These charges are imposed on new development as a way of recovering costs for that portion of existing system capacity solely attributable to new development or for that portion of required system up-sizing. System development charges can begin to answer questions of who should pay for required up-sizing of the stormwater system due to new development, or how historical payers into the system can recover their costs in oversizing facilities that enable future growth.

d. Fee-In-Lieu of On-Site Detention

These fees afford a land developer the option of either constructing an on-site stormwater detention facility in accordance with established design criteria, or paying a fee into a fund dedicated to the construction of an off-site or regional stormwater detention facility serving multiple properties. These fees tend to promote siting and construction of regional versus on-site detention facilities. However, cash flow necessary for a regional stormwater detention facility may not necessarily coincide with the required construction timing.

e. Local Improvement Districts and Special Assessments

The concept of deriving funding from local improvement or special assessment districts is founded on quantifying benefits. For water, sewer or street improvements, these benefits can often be easily identified and thus quantified. However, drainage differs in the respect that upstream or hillside properties that are major contributors of runoff may not be specific recipients of benefits.

f. Plan Review and Inspection Fees

These fees are intended to recover the expense of examining development plans to ensure consistency with comprehensive land use and stormwater master plans, and to ensure that construction standards and regulations are met at the construction site. These fees are not intended to be a primary revenue generating source.

g. Stormwater Service Charges

Another method gaining popularity for financing stormwater management is the utility-based service charge. Historically, the concept of considering stormwater as a public utility attracted very few communities. However, as other more conventional funding sources became difficult to obtain, and as federal requirements increase, the service charge concept has generated greater appeal. Service charges for stormwater management reflect a rationale that those who contribute to stormwater problems should logically contribute to the costs of providing mitigative services.

h. Ad Valorem Taxes

Ad valorem taxes are taxes levied on a property as a direct result of "value added" to the subject property. However, with stormwater there is no clear correlation between property value and contribution of runoff. Ad valorem taxes could provide a significant source of revenue, however with the apparent lack of equity, should not be considered a primary source for funding stormwater programs.

In addition to a System Development Charge (SDC), it is recommended that the City consider implementation of a stormwater service charge. A sample ordinance similar to that adopted by other small communities in the Willamette Valley is included in **Appendix F**.

REFERENCES

REFERENCES

1. Hydraulics Manual, Oregon Department of Transportation, Highway Division, prepared by the Hydraulics Unit, January 1990.

2. Drainage Management Study and Financial Program, City of Gresham, Oregon, prepared by KCM, December 1981.

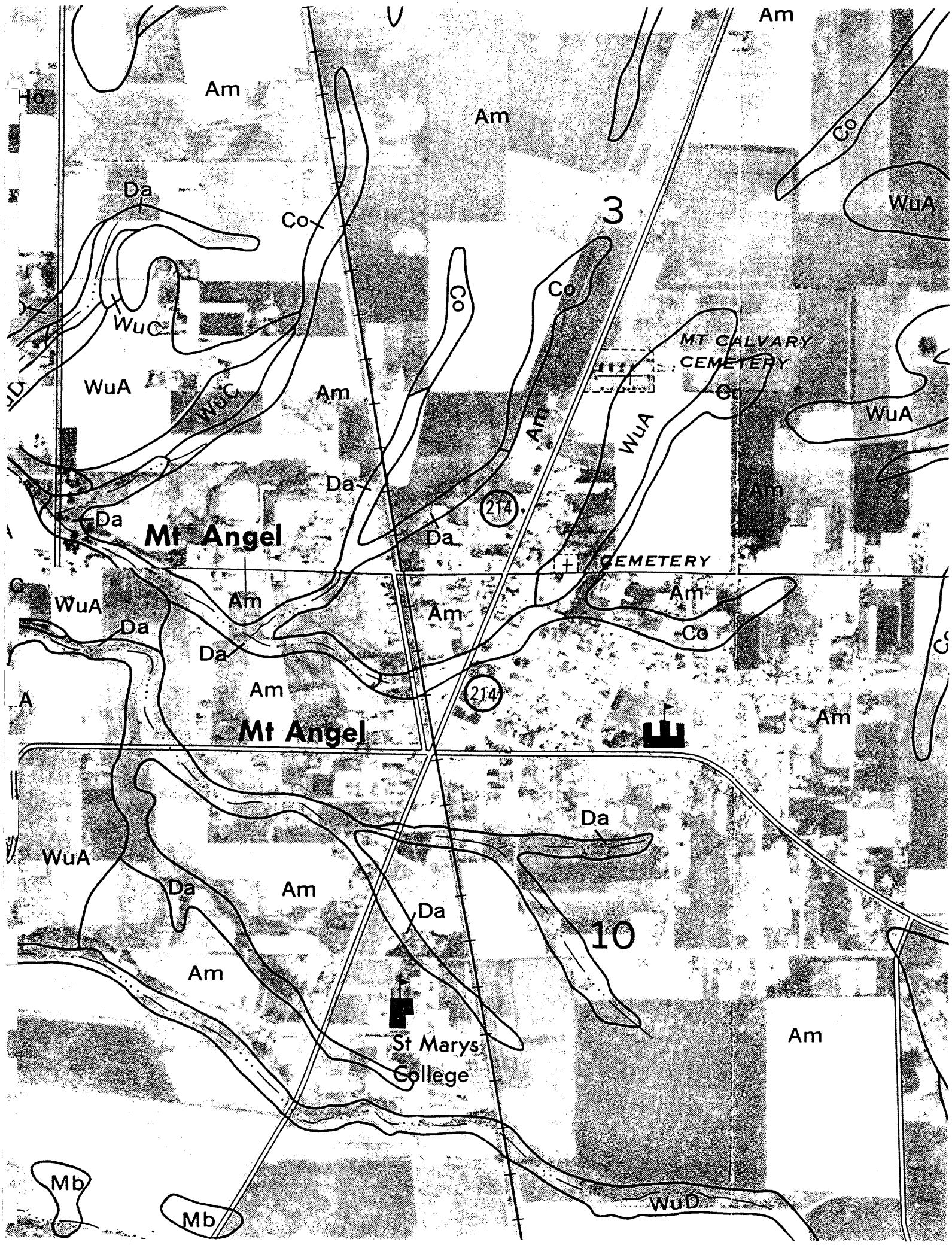
3. Kelly Creek Basin, Storm Drain Master Plan, City of Gresham, Oregon, prepared by URS, September 1988.

4. Comprehensive Storm Drainage Master Plan, City of Hillsboro, prepared by URS, July 1988.

CITY OF MT. ANGEL
Storm Drainage System Master Plan

Marion County Soil Survey Information

Appendix A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CITY OF MT. ANGEL
Storm Drainage System Master Plan

Mt. Angel Storm Drainage System Maps

Appendix B

IIB2t—19 to 24 inches, grayish-brown (2.5Y 5/2) heavy silty clay, light brownish gray (2.5Y 6/2) when dry; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; strong, fine, prismatic structure breaking to strong, medium and fine, angular blocky structure; firm, extremely hard, very sticky and very plastic; very few roots; many, very fine and few, fine and medium, tubular pores; few thin and moderately thick clay films on ped surfaces and in pores; many, fine, very dark brown and few black concretions; slightly acid (pH 6.4); clear, wavy boundary. (4 to 12 inches thick.)

IIB3t—24 to 29 inches, dark grayish-brown (2.5Y 4/2) silty clay, light brownish gray (2.5Y 6/2) when dry; many, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; massive; firm, very hard, sticky and plastic; few fine roots; common fine pores; common moderately thick clay films along lines of weakness, and few clay films in pores; few, fine, dark-brown and black concretions; neutral (pH 6.6); gradual, smooth boundary. (3 to 9 inches thick.)

IIIC—29 to 60 inches, dark grayish-brown (2.5Y 4/2) silt loam, light gray (2.5Y 7/2) when dry; many, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; friable, hard, sticky and plastic; massive; common, very fine, tubular pores; few black stains; neutral (pH 6.6).

The Ap horizon is dominantly silt loam, but the texture ranges to silty clay loam. In places texture of the IIB2t horizon is clay. Soil reaction ranges from medium acid in the A horizon to slightly acid and neutral in the B and C horizons.

Included with this soil in mapping were small areas of Dayton soils. These included soils make up from 5 to 10 percent of the acreage in the mapping unit.

The available water capacity ranges from 9 to 12 inches. Permeability is slow, and fertility is low. Runoff is slow, and ponding occurs in some areas, especially in depressions. The hazard of erosion is slight. Depth to which roots can penetrate is restricted by the silty clay in the subsoil. It is also restricted by wetness, caused by the poor drainage and by the seasonal high water table. This soil is easily worked, but it tends to compact if it is cultivated when too moist.

Areas of this soil that are neither drained nor irrigated are used for spring small grains, pasture, hay, and grass grown for seed. When irrigated, drained areas are used for berries and vegetables. This soil is well suited to vegetables, small grains, pasture, and hay. (Capability unit IIIw-2; not placed in a woodland suitability group)

Courtney Series

The Courtney series consists of poorly drained soils that have formed in alluvial deposits of different ages. These soils are on gravelly alluvial terraces, where they occur in shallow depressions and in drainageways. Slopes range from 0 to 2 percent, and elevations range from 175 to 650 feet. The average annual precipitation is 40 to 45 inches, the average annual air temperature is 52° to 54° F., and the length of the frost-free season is 190 to 210 days. In areas that are not cultivated, the vegetation is mainly ash, vine maple, hazel, wild rose, blackberry, rushes, sedges, and annual and perennial grasses. Courtney soils are associated with Salem and Clackamas soils.

In a typical profile, the surface layer is about 12 inches thick, and it consists of mottled, black gravelly silty clay loam in the upper part and of mottled, very dark gray gravelly silty clay loam in the lower part. The subsoil is mottled dark-gray gravelly clay about 12 inches thick. The substratum consists of a layer of dark grayish-b very gravelly clay loam, about 25 inches thick, that g to mottled, dark-brown very gravelly sand, which ex to a depth of 57 inches or more.

Undrained areas of Courtney soils are used main pasture, hay, and grass grown for seed. The drained are used for these crops and also for small grains.

Courtney gravelly silty clay loam (Cu).—This on terraces between Stayton and Salem. It is in depre and in narrow drainageways. This is the only soil Courtney series mapped in the survey area.

Representative profile (NW¼SE¼ sec. 6, T. 8 S. W.):

A11—0 to 4 inches, black (10YR 2/1) gravelly silty clay dark gray (10YR. 4/1) when dry; few, fine, d dark-brown (7.5YR 4/4) mottles; strong, medi fine, subangular blocky structure; friable, hard and plastic; many roots; many, very fine an interstitial pores; iron stains in root channels 25 percent coarse pebbles; strongly acid (pH clear, smooth boundary. (2 to 6 inches thick.)

A12—4 to 12 inches, very dark gray (7.5YR 3/0) gravel clay loam, very dark gray (10YR 3/1) when and dark gray (10YR 4/1) when dry; comm dium, distinct, strong-brown (7.5YR 4/4) m strong, medium and fine, subangular blocky ture; friable, hard, sticky and plastic; many many, very fine, tubular pores; iron stains channels; 30 percent pebbles; medium acid (p abrupt, smooth boundary. (7 to 10 inches thic

IIB2t—12 to 24 inches, dark-gray (10YR 4/1) gravell gray (10YR 5/1) when dry; few, fine, distinct n weak, coarse, prismatic structure; firm, ver very sticky and very plastic; few roots; 30 pebbles and a few cobblestones; slightly acid (p clear, smooth boundary, (10 to 20 inches thick.)

IIIC1—24 to 49 inches, dark grayish-brown (10YR 4/ gravelly clay loam, gray (10YR 5/1) when dr sive; firm, hard, sticky and plastic; iron sta percent pebbles; few cobblestones; slightly ac 6.2); abrupt, smooth boundary. (24 to 48 inches

IVC2—49 to 57 inches, mottled dark-brown (7.5YR 3/ gravelly sand, strong brown (7.5YR 5/6) when massive; friable, soft, nonsticky and nonplastic medium, interstitial pores; neutral (pH 6.7).

Color of the A horizon ranges from black or ve brown to very dark gray, and texture of that horizon from silty clay loam or clay loam to silty clay. In som the B horizon is very dark gray, and it is gravelly si in some areas. The amount of gravel in the B horizon from 20 to 30 percent. Depth to the very gravelly C ranges from 24 to 36 inches. The C horizon is stratifie the thickness of the different layers in the C horizon amount of gravel and cobblestones in that horizon ar variable.

Included with this soil in mapping were smal that have a surface layer of very dark gray silt lo

Above the clay subsoil, the available water cap less than 3 inches. Permeability is very slow, and f is moderate. Runoff is ponded or very slow, and the of erosion is slight. The depth to which roots ca trate is restricted by the claypan in the subsoil, ranges from 12 to 16 inches. Workability is fair.

Undrained areas of this soil are used for pastu and grass grown for seed. The drained areas are u these crops and also for spring small grains and wheat. When irrigated, the drained areas are u sweet corn, berries, and beans. This soil is used fo irrigated crops because it occupies only small ar extends through and is managed like the adjacent Salem, and Clackamas soils. Courtney soils are

d to row crops and root crops. (Capability unit w-1; not placed in a woodland suitability group)

ıley Series

:he Cumley series consists of moderately well drained s that have formed in glacial till and colluvium. These are on mountain foot slopes, and they have slopes of 20 percent. Elevations range from 800 to 2,000 feet. e average annual precipitation is between 55 and 75 hes, the average annual air temperature is 48° to 51° nd the length of the frost-free season is 165 to 190 . The vegetation is mainly Douglas-fir, maple, alder, ckenfern, and grasses. Cumley soils are associated with Cully, Kinney, and Minniece soils.

a typical profile, the surface layer is dark-brown clay loam about 9 inches thick. This is covered with ın layer of decomposing leaves, stems, and twigs. The soil is about 37 inches thick and is dark reddish-brown clay in the upper part, dark-brown heavy silty clay e middle part, and mottled brown clay in the lower ι. The substratum is mottled, olive-brown clay. Bedk is at a depth of more than 5 feet.

e Cumley soils are used mainly for timber and for shed.

umley silty clay loam, 2 to 20 percent slopes D).—This is the only soil of the Cumley series mapped e survey area. It occurs in small areas on foot slopes within slump areas of McCully soils.

epresentative profile 25 feet northwest of a logging d (NE¼NE¼ sec. 25, T. 9 S., R. 2 E.):

1 and O2—1 inch to 0, layer of duff consisting of partly decomposed leaves, stems, and twigs.

A11—0 to 4 inches, dark-brown (7.5YR 3/2) silty clay loam, dark brown (7.5YR 4/2) when dry; moderate, fine, granular structure; friable, hard, sticky and plastic; many, fine, interstitial pores; many roots; medium acid (pH 6.0); gradual, smooth boundary. (3 to 7 inches thick.)

A12—4 to 9 inches, dark-brown (7.5YR 3/2) silty clay loam, dark brown (7.5YR 4/2) when dry; moderate, fine and medium, subangular blocky structure; friable, hard, sticky and plastic; many, fine and very fine, tubular pores; many roots; slightly acid; clear, smooth boundary. (4 to 8 inches thick.)

B1—9 to 15 inches, dark reddish-brown (5YR 3/4) silty clay, dark brown (7.5YR 4/3) when dry; moderate, medium, subangular blocky structure; firm, very hard, sticky and plastic; common, very fine and fine, tubular pores; many roots; medium acid (pH 5.8); clear, smooth boundary. (4 to 9 inches thick.)

21t—15 to 25 inches, dark-brown (7.5YR 3/4) heavy silty clay, dark brown (7.5YR 4/4) when dry; moderate, coarse, subangular blocky structure; firm, very hard, very sticky and very plastic; common, very fine and fine, tubular pores; many roots; common thin and moderately thick clay films; common, fine, brown and black concretions; medium acid (pH 5.6). (8 to 14 inches thick.)

B22t—25 to 46 inches, brown (7.5YR 4/4) clay, brown (7.5YR 5/4) when dry; many, coarse, prominent, grayish-brown (2.5Y 5/2) mottles; moderate, coarse, subangular blocky structure; very firm, very hard, very sticky and very plastic; common, very fine and fine, tubular pores; common roots; nearly continuous, thin and moderately thick clay films; few coarse fragments of basalt; strongly acid; clear, smooth boundary. (17 to 25 inches thick.)

—46 to 60 inches, olive-brown (2.5Y 4/4) clay, grayish brown (2.5Y 5/2) when dry; many, coarse, strong-brown (7.5YR 4/4) mottles; massive; firm, very hard, very sticky and very plastic; few roots; few coarse fragments of basalt; common, very fine and fine, tubular pores; strongly acid.

Texture of the A horizon ranges from silty clay loam to silty clay. In places the A horizon is very dark brown. Mottling in the B22t horizon is distinct in some places. In some areas the entire profile contains a few pebbles, cobblestones, and other stones.

Included with this soil in mapping were small areas of Minniece soils and stony soils.

The available water capacity ranges from 9 to 12 inches. Permeability is moderately slow, and fertility is low. Runoff is medium, and the hazard of erosion is slight. The depth to which roots can penetrate is restricted by wetness and by the layer of clay at a depth of 46 inches.

This soil is used mainly for growing Douglas-fir to which it is moderately well suited. Where cleared, it can be used for small grains, pasture, hay, and grass grown for seed. If this soil is drained and irrigated, it is suitable for some vegetable and berry crops. (Capability unit IIIe-2; woodland suitability group 3c4)

Dayton Series

The Dayton series consists of soils that are poorly drained. These soils have formed mainly in old mixed alluvium, but their upper layers may have been influenced, to some extent, by loess. The soils are on broad valley terraces, and they occur in drainageways and in shallow depressions. Slopes range from 0 to 2 percent, and elevations range from 125 to 350 feet. The average annual precipitation is 40 to 45 inches, the average annual air temperature is 52° to 54° F., and the length of the frost-free season is 190 to 210 days. In areas that are not cultivated, the vegetation is mainly annual and perennial grasses, wild rose, and scattered ash trees. Dayton soils are associated with Amity and Concord soils.

In a typical profile, the surface layer is very dark grayish-brown silt loam about 7 inches thick. The subsurface layer is mottled dark-gray silt loam about 6 inches thick. The subsoil is mottled and consists of a layer of clay about 33 inches thick. It is dark gray in the upper part and is grayish brown in the lower part. The substratum is mottled grayish-brown silty clay loam that extends to a depth of 60 inches or more.

The Dayton soils are used mainly for small grains, pasture, hay, and grass grown for seed.

Dayton silt loam (Da).—This soil is on terraces, where it occupies small areas in drainageways and depressions. It is the only soil of the Dayton series mapped in the survey area.

Representative profile (SW¼NE¼ sec. 16, T. 6 S., R. 2 W.):

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, light brownish gray (10YR 6/2) when dry; few, fine, faint, yellowish-brown (10YR 5/6) mottles; moderate, fine, subangular blocky and granular structure; friable, hard, slightly sticky and slightly plastic; many roots; many, fine, interstitial pores; few, medium, black and red concretions; medium acid (pH 5.6); clear, smooth boundary. (5 to 9 inches thick.)

A2—7 to 13 inches, dark-gray (10YR 4/1) silt loam, gray (10YR 6/1) when dry; common, fine, faint, brownish-yellow (10YR 6/6) mottles; moderate, medium, subangular blocky structure; friable, slightly hard, slightly sticky and slightly plastic; many roots; common, very fine, tabular pores; few black and red concretions; medium

acid (pH 5.8); abrupt, smooth boundary. (4 to 15 inches thick.)

IIB21t—13 to 25 inches, dark-gray (10YR 4/1) clay, gray (10YR 5/1) when dry; moderate, medium, prismatic structure breaking to coarse and medium, subangular blocky structure; very firm, very hard, very sticky and very plastic; few roots; few, fine, tubular pores; thick, continuous clay films; few black and red concretions; slightly acid (pH 6.4); gradual, smooth boundary. (10 to 24 inches thick.)

IIB22t—25 to 46 inches, grayish-brown (10YR 5/2) clay, light brownish gray (10YR 6/2) when dry; few, fine, faint, yellowish-brown (10YR 5/6) mottles; massive; firm, very hard, very plastic and very sticky; few roots; few, fine, tubular pores; slightly acid (pH 6.4); gradual, smooth boundary.

IIIC—46 to 60 inches, grayish-brown (2.5Y 5/2) silty clay loam, light brownish gray (2.5Y 6/2) when dry; common, medium, faint, light olive-brown (2.5Y 5/6) mottles; massive; friable, hard, sticky and plastic; few, fine, tubualr pores; slightly acid (pH 6.2).

Color of the Ap horizon ranges from dark gray to very dark grayish brown when the soil is moist, and from light gray to light brownish gray when the soil is dry. Texture of the Ap horizon ranges from silt loam to silty clay loam.

Included with this soil in mapping were small areas of a Concord soil. The included areas make up as much as 5 percent of the acreage in the mapping unit.

The available water capacity above the clay subsoil is 3 to 6 inches. Permeability is very slow, and fertility is low. Runoff is very slow to ponded, and the hazard of erosion is slight. Roots can penetrate to the claypan, which is at a depth of only 12 to 24 inches. Workability is good, but this soil tends to puddle and compact if it is cultivated when too moist.

Undrained areas of this soil are used for small grains, pasture, hay, and grass grown for seed, and the drained areas are used for corn and for winter and spring small grains. When irrigated, this soil is used for sweet corn and bush beans. Even where it is drained, it is not suited to deep-rooted crops, many perennial crops, and crops that cannot tolerate excessive moisture. (Capability unit IVw-1; not placed in a woodland suitability group)

Hazelair Series

The Hazelair series consists of moderately well drained soils that formed in material weathered from sandstone and shale. These soils have slopes of 2 to 20 percent. They are on foot slopes adjacent to the valley floor, at elevations of 250 to 650 feet. The average annual precipitation is 40 to 60 inches, the average annual air temperature is 52° to 54° F., and the length of the frost-free season is 190 to 210 days. In areas that have not been cultivated, the vegetation is mainly Oregon white oak, poison-oak, rose, annual weeds and grasses, and a few Douglas-firs. Hazelair soils are associated with Steiwer soils.

In a typical profile, the surface layer is very dark brown silt loam about 12 inches thick. The subsoil is very dark grayish-brown silty clay loam about 6 inches thick. The substratum, about 20 inches thick, is mottled and is dark grayish brown throughout. It is silty clay in the upper part and clay in the lower part. Sandstone bedrock is at a depth of about 38 inches.

The Hazelair soils are used as woodland and for small grains, pasture, hay, and grass grown for seed.

Hazelair silt loam, 2 to 6 percent slopes (HaB).—This soil occupies small areas on the foot slopes of red foothills south of Salem. It also occurs near Scotts Mi

Representative profile 40 feet south of a gravel rc (NE¼NE¼ sec. 25, T. 9 S., R. 3 W.):

Ap—0 to 6 inches, very dark brown (10YR 2/2) silt loam, gr ish brown (10YR 5/2) when dry; weak, medium fine, granular structure; friable, slightly hard, sligh sticky and slightly plastic; few roots; common, v fine and fine, tubular and interstitial pores; comm fine, rounded concretions or fragments of rock; medi acid (pH 5.8); abrupt, smooth boundary. (6 10 inches thick.)

A1—6 to 12 inches, very dark brown (10YR 2/2) silt lo grayish brown (10YR 5/2) when dry; moderate, dium, subangular blocky structure breaking to stro very fine, subangular blocky structure; friable, sligh hard, slightly sticky and slightly plastic; few roo many, very fine and fine, tubular pores; common g silt coatings on ped surfaces; medium acid (pH 5.6 clear, smooth boundary. (3 to 6 inches thick.)

B2—12 to 18 inches, very dark grayish-brown (10YR 3/2) si clay loam, grayish brown (10YR 5/2) when dry; we medium, prismatic structure breaking to strong, f and very fine, subangular blocky structure; firm, ha plastic and sticky; few roots; many, very fine and fi tubular pores; slightly acid (pH 6.2); clear, smo boundary. (3 to 10 inches thick.)

IIC1—18 to 28 inches, dark grayish-brown (2.5Y 4/2) si clay, grayish brown (2.5Y 5/2) when dry; few, fai dark yellowish-brown (10YR 4/4) and few, distin light brownish-gray (10YR 6/2) mottles; strong, dium, angular blocky structure; firm, very hard, ve sticky and very plastic; few fine roots; common, ve fine, tubular pores; many slickensides; many, fine a very fine, black concretions; slightly acid (pH 6.2 gradual, wavy boundary. (5 to 10 inches thick.)

IIC2—28 to 36 inches, dark grayish-brown (2.5Y 4/2) cl grayish brown (2.5Y 5/2) when dry; many, medi and fine, distinct, dark yellowish-brown (10YR 4/ and few, distinct, light brownish-gray (10YR 6/2) m tles; moderate, very coarse and coarse, angular bloc structure; firm, very hard, very sticky and very pl tic; no roots; few, very fine, tubular pores; comm slickensides; few fine fragments of weathered sa stone; slightly acid (pH 6.4); gradual, wavy bou ary. (5 to 8 inches thick.)

IIC3—36 to 38 inches, dark grayish-brown (2.5Y 4/2) cla grayish brown (2.5Y 5/2) when dry; many, medi and fine, distinct, yellowish-brown (10YR 4/4) m tles; weak to moderate, coarse, angular blocky str ture; firm, very hard, very sticky and very plasti few, very fine, tubular pores; common slickenside common, fine, black concretions; many fine and m dium fragments of weathered sandstone; slightly a (pH 6.4); abrupt, slightly wavy boundary. (0 to inches thick.)

IIIR—38 inches, dark yellowish-brown (10YR 4/4), har fractured, fine-grained sandstone that is horizontal bedded.

Texture of the A horizon ranges from silt loam to silty cl loam. Mottles that are faint or distinct are within 20 inches the surface. Depth to the C horizon ranges from 12 to inches.

Included with this soil in mapping were small ston areas, and other areas where bedrock is at a depth of 4 t 5 feet.

The available water capacity is 4 to 7 inches. Perm ability is slow, and fertility is low. Runoff is slow, and th hazard of erosion is slight. The depth to which roots an water can penetrate is restricted by the layer of dense cla at some depth below 12 to 24 inches. Workability is fair. I this soil is cultivated when too moist, however, it tends t puddle and a tillage pan forms readily.

This soil is used mainly for small grains, pasture, ha and grass grown for seed. It is not suitable for fruit tree and deep-rooted crops, unless it is irrigated. When thi

to 54° F., and the length of the frost-free season is 190 to 200 days. The vegetation is mainly grass, poison-oak, rose, oak, and scattered Douglas-firs. Witzel soils are associated with Nekia and Jory soils.

In a typical profile, the surface layer is dark-brown very stony silt loam about 4 inches thick. The subsoil is about 15 inches thick, and it consists of dark-brown very stony silty clay loam in the upper part and of dark reddish-brown very stony silty clay loam in the lower part. Partly fractured basalt bedrock is at a depth of about 19 inches.

The Witzel soils are used mainly for pasture and as woodland.

Witzel very stony silt loam, 3 to 40 percent slopes (WtE).—This is the only soil of the Witzel series mapped in the survey area. It is on slope breaks and in red foothills. The dominant slopes are less than 12 percent.

Representative profile (NE¼SE¼ sec. 8, T. 8 S., R. 2 W.):

A1—0 to 4 inches, dark-brown (7.5YR 3/2) very stony silt loam, brown (7.5YR 5/4) when dry; moderate, fine, granular structure; friable, hard, slightly sticky and slightly plastic; 60 percent roots; many, very fine and fine, interstitial pores; many coarse fragments; medium acid (pH 6.0); clear, smooth boundary. (2 to 6 inches thick.)

B21—4 to 9 inches, dark-brown (7.5YR 3/2) very stony silty clay loam, brown (7.5YR 5/4) when dry; moderate, fine, subangular blocky structure; firm, hard, sticky and plastic; many roots; common, very fine, tubular pores; 60 percent coarse fragments; medium acid (pH 6.0); gradual, wavy boundary. (3 to 10 inches thick.)

B22—9 to 19 inches, dark reddish-brown (5YR 3/4) very stony silty clay loam, reddish brown (5YR 5/4) when dry; weak, medium, subangular blocky structure; friable, hard, sticky and plastic; many roots; common, very fine, tubular pores; 60 percent coarse fragments; medium acid (pH 6.0); clear, smooth boundary, (2 to 6 inches thick.)

IIR—19 inches, partly fractured basalt bedrock.

The A horizon ranges from silt loam to silty clay loam or clay loam in texture, and in places the B horizon is clay loam. Color of the B horizon ranges from dark brown to dark reddish brown. Thickness of the solum over basalt bedrock ranges from 12 to 20 inches. The content of coarse fragments of rock in the soil mass ranges from 50 to 75 percent.

Included with this soil in mapping were some areas in which bedrock is as deep as 30 inches.

The available water capacity is 1 to 3 inches. Permeability is moderately slow, and fertility is low. Roots can penetrate to a depth of 12 to 20 inches. Runoff is medium to rapid, and the hazard of erosion is moderate to high.

This soil is not used for cultivated crops, but it is used mainly for native pasture and as woodland. The high content of stones, low available water capacity, and hazard of erosion make this soil poorly suited to use for pasture. (Capability unit VIs-1; not placed in a woodland suitability group)

Woodburn Series

The Woodburn series consists of moderately well drained soils that have formed in silty alluvium and loess of mixed mineralogy. These soils are on broad valley terraces. They have slopes of 0 to 20 percent. Elevations range from 150 to 350 feet. The average annual precipitation is 40 to 45 inches, the average annual air temperature is 52° to 54° F., and the length of the frost-free season is 200 to 210 days. In areas that are not cultivated, the vegetation is mainly grass and Douglas-fir. Woodburn soils are associated with Willamette soils.

In a typical profile, the surface layer is about 17 inches thick and is very dark brown silt loam in the upper part and dark-brown silt loam in the lower part. The subsoil is about 37 inches thick. It is dark yellowish-brown silty clay loam in the upper part; mottled dark-brown silty clay loam in the middle part; and mottled, dark-brown silt loam in the lower part. The substratum is dark-brown silt loam that extends to a depth of 68 inches or more.

The Woodburn soils are used mainly for small grains, pasture, hay, orchards, berries, and vegetables.

Woodburn silt loam, 0 to 3 percent slopes (WuA).—This soil is on broad terraces of Willamette silts.

Representative profile about 200 feet west of the paved road to Champoeg (SW¼SE¼SE¼ sec. 2, T. 4 S., R. 2 W.; profile No. 5 in table 9 in the section "Laboratory Data."):

Ap—0 to 9 inches, very dark brown (10YR 2/2) silt loam, brown (10YR 5/3) when dry; cloddy and has very weak, subangular blocky structure; friable, slightly hard, slightly sticky and slightly plastic; many roots; many, fine and very fine, tubular pores; few, fine, interstitial pores; common, medium and fine, reddish-brown and black concretions; medium acid (pH 5.9); abrupt, smooth boundary. (6 to 10 inches thick.)

A1—9 to 17 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) when dry; moderate, medium, subangular blocky structure; friable, hard, slightly sticky and slightly plastic; common clean silt and sand grains on ped surfaces; many roots; many, very fine, tubular pores; few, thin, darker (10YR 2/2) coatings on ped surfaces; few reddish-brown and black concretions; slightly acid (pH 6.2); clear, smooth boundary. (3 to 8 inches thick.)

B21t—17 to 25 inches, dark yellowish-brown (10YR 3/4) silty clay loam, brown (7.5YR 5/4) when dry; moderate, coarse and medium, subangular blocky structure; friable, hard, sticky and plastic; common roots; many, very fine, tubular pores; few thin clay films on peds; few reddish-brown and black concretions; few black stains on ped surfaces; medium acid (pH 6.0); clear, smooth boundary. (7 to 9 inches thick.)

B22t—25 to 32 inches, dark-brown silty clay loam, brown (10YR 5/3) when dry; few, fine and medium, distinct, dark-gray (10YR 4/1) mottles, light brownish gray (10YR 6/2) when dry; moderate, medium and coarse, subangular blocky structure; friable, hard, brittle, sticky and plastic; common roots; many, very fine, tubular pores; continuous, moderately thick clay films on ped surfaces and in pores; few, fine, black concretions and stains on ped surfaces; medium acid (pH 5.8); abrupt, smooth boundary. (6 to 10 inches thick.)

B31t—32 to 39 inches, dark-brown (10YR 4/3) silt loam, brown (10YR 5/3) when dry; distinct, dark grayish-brown (10YR 4/2) mottles in a few root channels; thin, dark grayish-brown (10YR 4/2) coatings on plane surfaces, light gray (10YR 7/2) when dry; nearly massive; some planes of weakness that are indistinct; vertical planes are more distinct than horizontal planes; very firm, very hard, brittle, slightly sticky and slightly plastic; few roots; many, fine and very fine, tubular pores; continuous, moderately thick clay films on plane surfaces and in some root channels and pores; few, fine and medium, black concretions and few, black coatings on plane surfaces; medium acid (pH 5.7); gradual, smooth boundary. (7 to 10 inches thick.)

B32t—39 to 54 inches, dark-brown (10YR 4/3) silt loam, pale brown (10YR 6/3) when dry; nearly massive, and has some indistinct vertical planes of weakness; very firm, very hard, brittle, slightly sticky and slightly plastic;

Color of the A horizon is dark brown or very dark brown, and texture of that horizon ranges from silt loam to silty clay loam. Color of the B horizon ranges from dark brown to dark reddish brown. Texture of the B horizon ranges from silty clay to clay, except that the B3 horizon is silty clay loam in many places. In some areas a few angular pebbles are scattered throughout the profile.

Included with this soil in mapping were small areas that contain a layer of gravel below a depth of 40 inches. Also included were small areas of McAlpin and Waldo soils.

The available water capacity is 10 to 11 inches, permeability is moderately slow, and fertility is moderate. Runoff is slow, and the hazard of erosion is only slight. Where additions of organic matter are regularly supplied, workability of this soil is good. Depth to which roots can penetrate is not restricted.

This soil is used mainly for small grains, grass grown for seed, orchards, and pasture, but small areas are still in Douglas-fir. When this soil is irrigated, it is used for most of the crops commonly grown in the survey area. It is well suited to most crops, but it is not well suited to potatoes and carrots. (Capability unit I–1; not placed in a woodland suitability group)

Abiqua silty clay loam, 3 to 5 percent slopes (AbB).—This soil has a profile similar to the one described for Abiqua silty clay loam, 0 to 3 percent slopes, except that material washed from higher slopes has been deposited on the surface in a few places. Runoff is medium, and the hazard of erosion is slight.

This soil is used for about the same crops as Abiqua silty clay loam, 0 to 3 percent slopes. (Capability unit IIe–2; not placed in a woodland suitability group)

Alluvial Land

Alluvial land (Ad) occurs mostly along the Santiam, North Santiam, and Willamette Rivers, on or near the bed of the main stream, in overflow channels, and on islands or bars. It consists mostly of loose sand, gravel, and cobblestones, but it includes some small areas of silt loam. This material is frequently shifted by floodwaters, for this land type is subject to overflow in winter and spring.

In places this land type supports a good stand of cottonwoods, but use of these trees for timber is restricted by the very severe hazard of erosion if the trees are cut. Other areas have a cover of Douglas-fir. Still other small areas are bare, except for scattered willows. (Capability unit VIIw–1; not placed in a woodland suitability group)

Amity Series

The Amity series consists of somewhat poorly drained soils that have formed in mixed alluvial silts. These soils have slopes of 0 to 2 percent. They occur on broad valley terraces at elevations of 150 to 350 feet. The average annual precipitation is between 40 and 45 inches. The average annual air temperature is 52° to 54° F., and the length of the frost-free season is 190 to 210 days. In areas that are not cultivated, the vegetation is mainly grasses, shrubs, hardwoods, and scattered Douglas-firs. Amity soils are associated with Dayton and Concord soils.

In a typical profile, the surface layer is very dark grayish-brown silt loam that is mottled in the lower part and is about 17 inches thick. The subsurface layer is mottled dark-gray silt loam about 7 inches thick. The subsoil is mottled grayish-brown silty clay loam about 13 inches thick. A substratum of mottled olive-brown silt loam underlies the subsoil.

The Amity soils are used mainly for cereal grains, grass grown for seed, and pasture. When irrigated, areas that are drained can be used for all the crops commonly grown in the survey area.

Amity silt loam (Am).—This is the only soil of the Amity series mapped in the survey area. It occupies slightly convex or nearly level areas on terraces consisting of Willamette silts.

Representative profile 30 feet east of a paved road (SW¼SE¼ sec. 10, T. 5 S., R. 2 W.):

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; moderate, fine, subangular blocky structure; friable, slightly hard, slightly sticky and slightly plastic; abundant fine roots; many interstitial pores; medium acid (pH 6.0); clear, smooth boundary. (5 to 8 inches thick.)

A1—7 to 17 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; common, fine, faint, reddish-brown mottles; moderate, medium, subangular blocky structure; friable, hard, slightly sticky and slightly plastic; abundant fine roots; common interstitial pores and few, fine and medium, tubular pores; common, fine and medium, reddish-brown concretions; medium acid (pH 6.0); clear, smooth boundary. (5 to 10 inches thick.)

A2—17 to 24 inches, dark-gray (10YR 4/1) silt loam, gray (10YR 6/1) when dry; common, fine, faint, reddish-brown mottles; weak, medium, subangular blocky structure; friable, slightly hard, slightly sticky and slightly plastic; common fine roots; common interstitial pores and common, fine and medium, tubular pores; common, fine and medium, brown concretions; medium acid (pH 6.0); clear, wavy boundary. (4 to 8 inches thick.)

B21t—24 to 29 inches, grayish-brown (2.5Y 5/2) silty clay loam, light brownish gray (10YR 6/2 when dry; common, fine, distinct, reddish-brown mottles; weak, medium, prismatic structure breaking to moderate, coarse, subangular blocky structure; friable, hard, sticky and plastic; few fine roots; common, medium, tubular pores; thin, patchy clay films in pores, on vertical surfaces of peds, and on some horizontal surfaces of peds; common, fine, red and black concretions; slightly acid (pH 6.2); gradual, wavy boundary. (4 to 9 inches thick.)

B22t—29 to 37 inches, grayish-brown (2.5Y 5/2) silty clay loam, light brownish gray (2.5Y 6/2) when dry; common, fine, distinct, light yellowish-brown and black mottles; weak, medium, prismatic structure breaking to moderate, coarse, subangular blocky structure; friable, hard, sticky and plastic; few fine roots; few, medium and fine, tubular pores; thin, patchy clay films in pores and on vertical and horizontal surfaces of peds; many, fine, reddish-brown and few, fine, black concretions; slightly acid (pH 6.2); diffuse boundary. (5 to 14 inches thick.)

C—37 to 60 inches, olive-brown (2.5Y 4/4) silt loam, light yellowish brown (2.5Y 6/4) when dry; common, fine, faint, brown mottles; massive; friable, hard, slightly sticky and slightly plastic; few fine roots; few fine and medium pores; thick clay films in pores; slightly acid (pH 6.4).

When the soil is moist, color of the A horizon ranges from dark brown to very dark grayish brown. Texture of the B horizon is heavy silt loam in some areas, and the structural grade of that horizon is moderate in places. In some places the lower part of the B horizon is weakly to moderately brittle. Bedrock is at a depth of more than 60 inches.

Included with this soil is mapping were small areas of soils that are in drainageways and depressions and that

mottled grayish-brown silty clay loam about 13 inches thick. A substratum of mottled olive-brown silt loam underlies the subsoil.

The Amity soils are used mainly for cereal grains, grass grown for seed, and pasture. When irrigated, areas that are drained can be used for all the crops commonly grown in the survey area.

Amity silt loam (Am).—This is the only soil of the Amity series mapped in the survey area. It occupies slightly convex or nearly level areas on terraces consisting of Willamette silts.

Representative profile 30 feet east of a paved road (SW¼SE¼ sec. 10, T. 5 S., R. 2 W.):

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; moderate, fine, subangular blocky structure; friable, slightly hard, slightly sticky and slightly plastic; abundant fine roots; many interstitial pores; medium acid (pH 6.0); clear, smooth boundary. (5 to 8 inches thick.)

A1—7 to 17 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; common, fine, faint, reddish-brown mottles; moderate, medium, subangular blocky structure; friable, hard, slightly sticky and slightly plastic; abundant fine roots; common interstitial pores and few, fine and medium, tubular pores; common, fine and medium, reddish-brown concretions; medium acid (pH 6.0); clear, smooth boundary. (5 to 10 inches thick.)

A2—17 to 24 inches, dark-gray (10YR 4/1) silt loam, gray (10YR 6/1) when dry; common, fine, faint, reddish-brown mottles; weak, medium, subangular blocky structure; friable, slightly hard, slightly sticky and slightly plastic; common fine roots; common interstitial pores and common, fine and medium, tubular pores; common, fine and medium, brown concretions; medium acid (pH 6.0); clear, wavy boundary. (4 to 8 inches thick.)

B21t—24 to 29 inches, grayish-brown (2.5Y 5/2) silty clay loam, light brownish gray (10YR 6/2 when dry; common, fine, distinct, reddish-brown mottles; weak, medium, prismatic structure breaking to moderate, coarse, subangular blocky structure; friable, hard, sticky and plastic; few fine roots; common, medium, tubular pores; thin, patchy clay films in pores, on vertical surfaces of peds, and on some horizontal surfaces of peds; common, fine, red and black concretions; slightly acid (pH 6.2); gradual, wavy boundary. (4 to 9 inches thick.)

B22t—29 to 37 inches, grayish-brown (2.5Y 5/2) silty clay loam, light brownish gray (2.5Y 6/2) when dry; common, fine, distinct, light yellowish-brown and black mottles; weak, medium, prismatic structure breaking to moderate, coarse, subangular blocky structure; friable, hard, sticky and plastic; few fine roots; few, medium and fine, tubular pores; thin, patchy clay films in pores and on vertical and horizontal surfaces of peds; many, fine, reddish-brown and few, fine, black concretions; slightly acid (pH 6.2); diffuse boundary. (5 to 14 inches thick.)

C—37 to 60 inches, olive-brown (2.5Y 4/4) silt loam, light yellowish brown (2.5Y 6/4) when dry; common, fine, faint, brown mottles; massive; friable, hard, slightly sticky and slightly plastic; few fine roots; few fine and medium pores; thick clay films in pores; slightly acid (pH 6.4).

When the soil is moist, color of the A horizon ranges from dark brown to very dark grayish brown. Texture of the B horizon is heavy silt loam in some areas, and the structural grade of that horizon is moderate in places. In some places the lower part of the B horizon is weakly to moderately brittle. Bedrock is at a depth of more than 60 inches.

Included with this soil is mapping were small areas of soils that are in drainageways and depressions and that have slopes of 2 to 5 percent. Also included were small areas of Woodburn and Concord soils.

The available water capacity ranges from 9 to 12 inches. Permeability is moderately slow, and fertility is moderate. Runoff is slow, and erosion is not a hazard or is only a slight hazard. The depth to which roots can penetrate is moderately restricted by wetness, partly caused by a high water table that is near the surface during winter and spring. Workability is good, but this soil compacts easily if it is cultivated when wet.

Undrained areas of this soil are used for small grains, pasture, and grasses grown for seed, but drainage is needed for berries, vegetables, and specialty crops. If this soil is drained and irrigated, it can be used for all the crops commonly grown in the survey area. Even after drainage is installed, however, there are slight restrictions to use of this soil for deep-rooted crops that cannot tolerate excessive moisture. Nevertheless, response to drainage and fertilizer is generally good. (Capability unit IIw-2; not placed in a woodland suitability group)

Bashaw Series

The Bashaw series consists of poorly drained and very poorly drained soils that have formed in alluvium. These soils are in backwater areas of the flood plains and in drainage channels of silty alluvial terraces. They have slopes of 0 to 1 percent. Elevations range from 100 to 400 feet. The average annual precipitation is between 40 and 45 inches, the average annual air temperature is 52° to 54° F., and the length of the frost-free season is 200 to 210 days. In areas that are not cultivated, the vegetation is mainly annual and perennial grasses, wild blackberries, sedges, rushes, willows, and a few ash and oak trees. Bashaw soils are associated with Wapato soils.

In a typical profile, the surface layer is about 31 inches thick and consists of mottled very dark gray clay in the uppermost 3 inches and of mottled black clay below. The upper part of the substratum, just beneath the surface layer, is very dark gray clay that extends to a depth of 48 inches. The lower part of the substratum is dark grayish-brown clay or sandy clay that extends to a depth of 60 inches or more. The substratum is mottled throughout.

The Bashaw soils are used mainly for pasture.

Bashaw clay (Ba).—This is the only soil of the Bashaw series mapped in the survey area. It occupies concave backwater areas adjacent to silty alluvial terraces, and it is also in drainage channels on the terraces. The areas are small.

Representative profile (NW¼SW¼NE¼ sec. 9, T. 6 S., R. 1 W.):

A11—0 to 3 inches, very dark gray (10YR 3/1) clay, dark gray (10YR 4/1) when dry; many, fine, distinct, yellowish-red (5YR 4/6) mottles; moderate, medium and fine, subangular blocky structure; firm, very hard, very sticky and very plastic; common roots; many very fine pores; medium acid (pH 5.8); abrupt, smooth boundary. (0 to 4 inches thick.)

A12g—3 to 14 inches, black (N 2/0) clay, very dark gray (N 3/0) when dry; few, fine, distant, yellowish-red (5YR 5/6) mottles; massive when wet; weak, coarse, prismatic structure breaking to weak, coarse, angular blocky structure when moist or dry; very firm, very hard, very sticky and very plastic; common very fine roots; many very fine pores; common, fine, red

cottonwood, bigleaf maple, Oregon white oak, ash, and n understory of vine maple, wild blackberry, vines, hrubs, and grasses. Cloquato soils are associated with ehalis and Newberg soils.

n a typical profile, the surface layer is dark-brown silt oam about 9 inches thick. The subsoil, which is also dark-rown silt loam, is about 56 inches thick. The substratum lark-brown fine sandy loam that extends to a depth of nches or more.

Cloquato soils that are not irrigated are used mainly for mall grains, orchards, pasture, hay, and grass grown for d. When irrigated, these soils are used for all the crops mmonly grown in the survey area.

Cloquato silt loam (Cm).—This is the only Cloquato oil mapped in the survey area. It occupies large areas ng the Willamette, Pudding, and Santiam Rivers and ng Butte Creek.

Representative profile (E½SE¼ sec. 20, T. 6 S., R. W.):

Ap—0 to 9 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) when dry; weak, medium and coarse, subangular blocky structure; friable, slightly hard, slightly sticky and slightly plastic; many roots; many, fine and very fine, tubular pores; medium acid (pH 6.0); clear, smooth boundary. (6 to 10 inches thick.)

B2—9 to 41 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) when dry; weak, medium, subangular blocky structure; friable, slightly hard, slightly sticky and slightly plastic; common roots; many, very fine, tubular pores; slightly acid (pH 6.2); gradual, smooth boundary. (15 to 35 inches thick.)

B3—41 to 65 inches, dark-brown (10YR 4/3) silt loam, pale brown (10YR 6/3) when dry; very weak, coarse, subangular blocky structure; very friable, slightly hard, slightly sticky and nonplastic; few roots; many, fine, tubular pores; slightly acid (pH 6.4); clear, smooth boundary. (0 to 25 inches thick.)

C—65 to 83 inches, dark-brown (10YR 4/3) fine sandy loam, pale brown (10YR 6/3) when dry; massive; very friable, soft, nonsticky and nonplastic; no roots; many fine pores; slightly acid (pH 6.4).

Texture of the B2 horizon is dominantly silt loam, but this horizon contains thin layers of sandy material in places. This sandy material is generally below a depth of 30 inches.

Included with this soil in mapping were small areas of Chehalis, Newberg, and Camas soils, and small areas in ich the substratum is gravelly. Also included were areas steeper soils that have short slopes and that are adjacent o sloughs and old stream channels. The included areas make up from 10 to 15 percent of the acreage in this pping unit.

The available water capacity is 12 to 14 inches. Permeability is moderate, and fertility is high. Runoff is slow, ut the hazard of erosion is slight to moderate as the ult of periodic overflow. Overflow generally occurs out once in 3 or 4 years, but it occurs two or more times in some years. Roots can penetrate to a depth of 5 feet or ore. Workability is very good.

This soil is used mainly for small grains, orchards, pasture, hay, and grass grown for seed. When irrigated, it is used for all the crops commonly grown in the survey area.

This soil is well suited to all the commonly grown crops. oodwaters leave debris, and they can erode deep holes in orchards and in areas occupied by other permanent crops. (Capability unit IIw-3; not placed in a woodland itability group)

Concord Series

The Concord series consists of poorly drained soils that have formed in alluvium of mixed mineralogy. These soils are on broad valley terraces, in slightly concave depressions and in drainageways. They have slopes of 0 to 2 percent. Elevations range from 125 to 350 feet. The average annual precipitation is 40 to 45 inches, the average annual air temperature is 52° to 54° F., and the length of the frost-free season is 200 to 210 days. In areas that are not cultivated, the vegetation is mainly rushes, sedges, wild blackberry, hazel, annual grasses, and ash trees. Concord soils are associated with Amity and Dayton soils.

In a typical profile, the surface layer is very dark grayish-brown silt loam about 6 inches thick. The subsurface layer is mottled dark-gray silt loam about 9 inches thick. Just below the subsurface layer is a layer of mottled gray and dark-gray silty clay about 4 inches thick. The subsoil is about 10 inches thick. It consists of mottled grayish-brown silty clay in the upper part and of mottled dark grayish-brown silty clay in the lower part. The substratum of mottled dark grayish-brown silt loam extends to a depth of 60 inches or more.

Concord soils that are neither drained nor irrigated are used mainly for cereal grains, pasture, hay, and grass grown for seed. When irrigated, the drained areas are used mainly for berries and vegetables.

Concord silt loam (Co).—This is the only soil of the Concord series mapped in the survey area. It occupies narrow strips along and at the heads of drainageways, and it is also in depressions on terraces. In most places the slope is less than 2 percent.

Representative profile at the eastern edge of the Baldock Freeway, 200 feet north of the overpass (NE¼NE¼ NW¼ sec. 33, T. 5 S., R. 2 W.):

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam, light brownish gray (10YR 6/2) when dry; moderate, fine, subangular blocky structure breaking to moderate, fine, granular structure; friable, hard, sticky and plastic; abundant fine roots; many interstitial pores and wormholes; common, fine, brown concretions; medium acid (pH 6.0); abrupt, smooth boundary. (5 to 7 inches thick.)

A21—6 to 9 inches, dark-gray (10YR 4/1) silt loam, gray (10YR 6/1) when dry; common, fine, distinct, dark-brown (7.5YR 4/2) mottles; moderate, medium, subangular blocky structure; friable, hard, sticky and plastic; abundant fine roots; many, very fine and few, fine, tubular pores; common, fine, very dark brown concretions; medium acid (pH 5.8); clear, smooth boundary. (1 to 6 inches thick.)

A22—9 to 15 inches, dark-gray (10YR 4/1) heavy silt loam, light gray (10YR 7/1) when dry; common, fine, distinct, dark-brown (7.5YR 4/4) mottles; weak, medium, prismatic structure breaking to moderate, medium, subangular blocky structure; friable, hard, sticky and plastic; few fine roots; many, very fine and common, fine, tubular pores; common, fine, very dark brown concretions; medium acid (pH 6.0); clear, smooth boundary. (4 to 9 inches thick.)

A&B—15 to 19 inches, gray (10YR 5/1) and dark-gray (10YR 4/1) light silty clay, light gray (10YR 7/1 and 10YR 6/1) when dry; darker colors in ped interiors; common, fine, distinct, dark-brown (7.5YR 4/4) mottles; weak, medium, prismatic structure breaking to moderate, medium, subangular blocky structure; friable, hard, sticky and plastic; few fine roots; many, very fine, tubular pores; many, fine, very dark brown concretions; slightly acid (pH 6.2); clear, smooth boundary. (2 to 7 inches thick.)

no roots; many, fine and very fine, and few, medium, tubular pores; continuous, thin clay films in pores and in old root channels; few black concretions, and some patchy, black coatings on plane surfaces; medium acid (pH 5.9); gradual, wavy boundary. (11 to 17 inches thick.)

C—54 to 68 inches, dark-brown (10YR 4/3) silt loam, pale brown (10YR 6/3) when dry; massive; very firm, very hard, brittle, slightly sticky and slightly plastic; no roots; many, very fine, tubular pores; common moderately thick clay films in larger pores and in old root channels or worm channels; few black coatings in pores and in channels; medium acid (pH 5.9); gradual, wavy boundary. (14 to 16 inches thick.)

When the soil is moist, color of the A horizon ranges from dark grayish brown to very dark brown or dark brown, and color of the B2 horizon ranges from very dark grayish brown or dark brown to dark yellowish brown or strong brown. In all areas the A horizon is thicker than 10 inches. The B2 horizon ranges from heavy silt loam to silty clay loam in texture. Structure of the B2 horizon ranges from weak to moderate, medium or coarse, prismatic to moderate, fine to coarse, subangular blocky. Distinct mottling occurs at a depth above 30 inches. In some places the B3 horizon has weak to moderate subangular blocky or prismatic structure. In others it is massive and has vertical planes of weakness. Consistence of the B3 horizon is firm or very firm when the soil is moist. The substratum is stratified. It ranges from silty clay loam or silt loam to very fine sandy loam or fine sandy loam in texture.

Included with this soil in mapping were small areas of Amity and Willamette soils, and small areas of a somewhat poorly drained soil. The areas of Amity soils occupy less than 5 percent of the acreage in this mapping unit. The areas of Willamette soils occupy as much as 10 percent.

The available water capacity is 11 to 13 inches. Permeability is moderate in the upper part of the subsoil, and it is slow in the lower part. Fertility is high. Depth to which roots can penetrate is restricted by a seasonal perched water table and as the result of the type of structure. Runoff is slow, and no apparent erosion has taken place.

This soil is used mainly for small grains, field corn, orchards, pasture, hay, caneberries, and vegetables. Areas that are drained are used for all the crops commonly grown in the survey area. Because of the perched water table, drainage is needed for crops that cannot tolerate excessive moisture. (Capability unit IIw–1; not placed in a woodland suitability group)

Woodburn silt loam, 3 to 12 percent slopes (WuC).—This soil has slopes of 3 to 5 percent in about 60 percent of the acreage. Runoff is slow to medium, and the hazard of erosion is slight to moderate.

Included with this soil in mapping were small areas that have a thin surface layer and that have distinct mottling within 12 inches of the surface.

This Woodburn soil is used for about the same crops as Woodburn silt loam, 0 to 3 percent slopes. It is less suitable for vegetables and berries, however, because of the difficulty of cultivating those crops so that erosion is controlled without damaging the crop. Mechanical harvesting of vegetables and berries is difficult where slopes are steeper than 5 percent. (Capability unit IIe–1; not placed in a woodland suitability group)

Woodburn silt loam, 12 to 20 percent slopes (WuD).—Where this soil occurs along creeks, intermittent drainageways, and terrace fronts, its slopes are short and abrupt. Runoff is rapid, and the hazard of erosion is moderate.

Included with this soil in mapping were small areas that have a thin surface layer and that have distinct mottling within 12 inches of the surface.

This Woodburn soil is used mainly for pasture, hay, and small grains, although some small areas are used for row crops and orchards. This soil is poorly suited to row crops, for the slopes are too short and steep for mechanical harvesting of vegetables, berries, and other row crops to be feasible. Tilling row crops so that excessive soil losses are avoided is also difficult. (Capability unit IIIe–1; not placed in a woodland suitability group)

Formation and Classification of Soils

Soils of the Marion County Area differ in fertility, in physical and chemical properties, and in productivity. These differences are the result of differences in parent material and of local differences in the environment under which the soils have formed. This section describes some factors in the environment, and major processes that have affected the formation of soils of the Marion County Area. It also defines the current system for classifying soils and shows the classification of the soils by series and by higher categories.

Formation of Soils

Soil is a natural body on the surface of the earth. It consists of mixtures of rocks and minerals that have been subjected to various degrees of weathering and that contain greatly varying amounts of organic matter, water, and air. Soils have more or less distinct horizons that have developed under the influence of local factors in the environment. The soil-forming processes that produce different kinds of soils are parent material, which affects the physical and chemical composition of the soils; climate, principally precipitation and temperature; biological forces, or the plant and animal life in and on the soil; relief, or topography; and the time in which the soil-forming processes have acted on the parent material. These five factors, in many different combinations and intensities, produce soils that differ from place to place. The influence of each soil-forming factor on the soils of the Marion County Area is described in the following paragraphs.

Parent material

Soils in the survey area have formed in eight major kinds of parent material. These are (1) recent alluvium, (2) gravelly alluvium, (3) young, silty terrace alluvium, (4) weakly consolidated, old gravelly alluvium, (5) basic colluvium from basalt and massive tuffs, (6) sedimentary alluvium and colluvium derived from tuffaceous sandstone and shale, (7) glacial till, and (8) deposits of organic material. The soils in about 80 percent of the survey area have formed in recent alluvium (Willamette silts); in basic igneous material (basic colluvium derived from basalt and massive tuffs); or in glacial till. Figure 10 shows the approximate distribution of the different kinds of parent materials in the survey area. This figure is based only partly on the results of geologic studies, and therefore it cannot be called a geologic map. The distribution shown is the result of combining information obtained

CITY OF MT. ANGEL
Storm Drainage System Master Plan

Sub-Basin Summaries

Appendix C

Mt. Angel Storm Drain Master Plan
JO 447.5030.0
Apr-02

BASIN CHARACTERISTICS - FUTURE CONDITIONS
NORTH BASIN

2-yr 24 hr Rainfall 2.5 inches

Sub-Basin N1

Area	CN	Description
8	84	RL-UGB
4.1	84	RS
5.2	80	P
1.4	93	STREET
18.7	84	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.47	Sheet Flow	0.24	200	0.02

		Length	Slope	Paved?
0.04	Shallow Overland	500	0.04	n

		Length	Velocity
0.00	Length & Velocity	0	2

0.51 TOTAL (hours)

Sub-Basin N2

Area	CN	Description
1.3	84	RL-UGB
13	91	RM
0.8	84	RS
4	97	STREET
0.3	80	P
19.4	91	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.11	Sheet Flow	0.08	100	0.02

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.07	Length & Velocity	1500	6

0.21 TOTAL (hours)

Sub-Basin N3

Area	CN	Description
0.9	82	EFU
10.2	84	RL-UGB
9.8	84	RS
0.9	93	STREET
21.8	84	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.24	Sheet Flow	0.15	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.04	Length & Velocity	800	6

0.31 TOTAL (hours)

Sub-Basin N4

Area	CN	Description
4.3	91	RM
6.7	84	RS
4.5	97	STREET
15.5	90	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.24	Sheet Flow	0.15	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.04	Length & Velocity	800	6

0.31 TOTAL (hours)

Mt. Angel Storm Drain Master Plan
JO 447.5030.0
Apr-02

BASIN CHARACTERISTICS - FUTURE CONDITIONS
NORTH BASIN

2-yr 24 hr Rainfall 2.5 inches

Sub-Basin N5

Area	CN	Description
6.6	91	RM
2.4	97	STREET
9	93	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.15	Sheet Flow	0.08	100	0.01

		Length	Slope	Paved?
0.12	Shallow Overland	1000	0.02	n

		Length	Velocity
0.02	Length & Velocity	400	6

0.29 TOTAL (hours)

Sub-Basin N6

Area	CN	Description
17.9	91	I
24.8	91	I-UGB
4.6	84	RS
3.2	97	STREET
50.5	91	Sub-Basin Total

		'n'	Length	Slope
0.26	Sheet Flow	0.08	200	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.11	Length & Velocity	2400	6

0.40 TOTAL (hours)

Sub-Basin N7

Area	CN	Description
5.4	84	RS
2.4	91	RM
0.6	92	CR
0.8	94	CG
3.8	97	STREET
13	90	Sub-Basin Total

		'n'	Length	Slope
0.24	Sheet Flow	0.15	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	Y

		Length	Velocity
0.05	Length & Velocity	1000	6

0.32 TOTAL (hours)

Sub-Basin N8

Area	CN	Description
5	94	CG
3.5	97	STREET
8.5	95	Sub-Basin Total

		'n'	Length	Slope
0.15	Sheet Flow	0.08	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.03	Length & Velocity	500	4

0.21 TOTAL (hours)

Mt. Angel Storm Drain Master Plan
JO 447.5030.0
Apr-02

BASIN CHARACTERISTICS - FUTURE CONDITIONS
NORTH BASIN

2-yr 24 hr Rainfall 2.5 inches

Sub-Basin N9

Area	CN	Description
3.4	94	CG
2.3	92	CR
7.2	84	RS
0.8	91	RM
13.3	91	I
5.3	97	STREET
32.3	91	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.24	Sheet Flow	0.15	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.09	Length & Velocity	2000	6

0.36 TOTAL (hours)

Sub-Basin N10

Area	CN	Description
1.4	94	Grass Land
7.5	92	
2.8	91	
0.2	84	
0.6	91	
7.2	84	
11	84	
0.4	91	
5.7	97	
36.8	89	Sub-Basin Total

		'n'	Length	Slope
0.24	Sheet Flow	0.15	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.11	Length & Velocity	2400	6

0.38 TOTAL (hours)

Sub-Basin N11

Area	CN	Description
8.4	87	P
22	84	RS
1.6	94	CG
0.5	91	CR
11.4	97	STREET
43.9	88	Sub-Basin Total

		'n'	Length	Slope
0.18	Sheet Flow	0.15	100	0.02

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.10	Length & Velocity	2200	6

0.31 TOTAL (hours)

Sub-Basin N12

Area	CN	Description
20.6	84	RS
2.1	97	STREET
22.7	85	Sub-Basin Total

		'n'	Length	Slope
0.24	Sheet Flow	0.15	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.06	Length & Velocity	1200	6

0.33 TOTAL (hours)

Mt. Angel Storm Drain Master Plan
JO 447.5030.0
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BASIN CHARACTERISTICS - FUTURE CONDITIONS
NORTH BASIN

2-yr 24 hr Rainfall 2.5 inches

Sub-Basin N13

Area	CN	Description
0.9	84	RS
0.8	91	RM
51.1	88	P
12.6	84	RL-UGB
1.6	97	STREET
67	87	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.62	Sheet Flow	0.24	200	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	n

		Length	Velocity
0.07	Length & Velocity	1600	6

0.73	TOTAL (hours)

Sub-Basin N14

Area	CN	Description
4.8	88	P
16.7	84	RS
3.2	97	STREET
24.7	86	Sub-Basin Total

		'n'	Length	Slope
0.24	Sheet Flow	0.15	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.07	Length & Velocity	1600	6

0.35	TOTAL (hours)

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BASIN CHARACTERISTICS - EXISTING CONDITIONS
NORTH BASIN

2-yr 24 hr Rainfall 2.5 inches

Sub-Basin N1

Area	CN	Description
8	80	RL-UGB
4.1	81	RS
5.2	80	P
1.4	93	STREET
18.7	81	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.47	Sheet Flow	0.24	200	0.02

		Length	Slope	Paved?
0.04	Shallow Overland	500	0.04	n

		Length	Velocity
0.00	Length & Velocity	0	2

0.51 TOTAL (hours)

Sub-Basin N2

Area	CN	Description
1.3	82	RL-UGB
13	83	RM
0.8	84	RS
4	95	STREET
0.3	80	P
19.4	85	Sub-Basin Total

		'n'	Length	Slope
0.37	Sheet Flow	0.24	150	0.02

		Length	Slope	Paved?
0.02	Shallow Overland	150	0.02	n

		Length	Velocity
0.03	Length & Velocity	700	6

0.42 TOTAL (hours)

Sub-Basin N3

Area	CN	Description
0.9	82	EFU
10.2	82	RL-UGB
9.8	82	RS
0.9	93	STREET
21.8	82	Sub-Basin Total

		'n'	Length	Slope
0.62	Sheet Flow	0.24	200	0.01

		Length	Slope	Paved?
0.02	Shallow Overland	200	0.02	n

		Length	Velocity
0.02	Length & Velocity	500	6

0.67 TOTAL (hours)

Sub-Basin N4

Area	CN	Description
4.3	91	RM
6.7	84	RS
4.5	97	STREET
15.5	90	Sub-Basin Total

		'n'	Length	Slope
0.24	Sheet Flow	0.15	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.04	Length & Velocity	800	6

0.31 TOTAL (hours)

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JO 447.5030.0
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BASIN CHARACTERISTICS - EXISTING CONDITIONS
NORTH BASIN

2-yr 24 hr Rainfall 2.5 inches

Sub-Basin N5

Area	CN	Description
6.6	89	RM
2.4	97	STREET
9	91	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.15	Sheet Flow	0.08	100	0.01

		Length	Slope	Paved?
0.12	Shallow Overland	1000	0.02	n

		Length	Velocity
0.02	Length & Velocity	400	6

0.29 TOTAL (hours)

Sub-Basin N6

Area	CN	Description
17.9	88	I
24.8	82	I-UGB
4.6	84	RS
3.2	97	STREET
50.5	85	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.62	Sheet Flow	0.24	200	0.01

		Length	Slope	Paved?
0.10	Shallow Overland	600	0.01	n

		Length	Velocity
0.09	Length & Velocity	2000	6

0.81 TOTAL (hours)

Sub-Basin N7

Area	CN	Description
5.4	83	RS
2.4	85	RM
0.6	91	CR
0.8	94	CG
3.8	97	STREET
13	89	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.24	Sheet Flow	0.15	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	Y

		Length	Velocity
0.05	Length & Velocity	1000	6

0.32 TOTAL (hours)

Sub-Basin N8

Area	CN	Description
5	94	CG
3.5	97	STREET
8.5	95	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.15	Sheet Flow	0.08	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.03	Length & Velocity	500	4

0.21 TOTAL (hours)

Mt. Angel Storm Drain Master Plan
JO 447.5030.0
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BASIN CHARACTERISTICS - EXISTING CONDITIONS
NORTH BASIN

2-yr 24 hr Rainfall 2.5 inches

	Area	CN	Description	Time of Concentration		'n' / Length / Slope	Length / Slope / Paved?	Length / Velocity
Sub-Basin N9	3.4	90	CG	0.47	Sheet Flow	0.24 / 200 / 0.02		
	2.3	84	CR					
	7.2	84	RS					
	0.8	91	RM	0.03	Shallow Overland		200 / 0.01 / y	
	13.3	88	I					
	5.3	97	STREET					
				0.06	Length & Velocity			1200 / 6
	32.3	89	Sub-Basin Total	0.55	TOTAL (hours)			
Sub-Basin N10	1.4	94	Grass Land	0.47	Sheet Flow	0.24 / 200 / 0.02		
	7.5	82						
	2.8	88						
	0.2	84		0.03	Shallow Overland		200 / 0.01 / n	
	0.6	91						
	7.2	82						
	11	82		0.11	Length & Velocity			2400 / 6
	0.4	82						
	5.7	97						
	36.8	85	Sub-Basin Total	0.61	TOTAL (hours)			
Sub-Basin N11	8.4	87	P	0.18	Sheet Flow	0.15 / 100 / 0.02		
	22	84	RS					
	1.6	94	CG					
	0.5	91	CR	0.03	Shallow Overland		200 / 0.01 / y	
	11.4	97	STREET					
				0.10	Length & Velocity			2200 / 6
	43.9	88	Sub-Basin Total	0.31	TOTAL (hours)			
Sub-Basin N12	20.6	83	RS	0.24	Sheet Flow	0.15 / 100 / 0.01		
	2.1	97	STREET					
				0.03	Shallow Overland		200 / 0.01 / y	
				0.06	Length & Velocity			1200 / 6
	22.7	84	Sub-Basin Total	0.33	TOTAL (hours)			

Mt. Angel Storm Drain Master Plan
JO 447.5030.0
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BASIN CHARACTERISTICS - EXISTING CONDITIONS
NORTH BASIN

2-yr 24 hr Rainfall 2.5 inches

Sub-Basin N13

Area	CN	Description
0.9	84	RS
0.8	91	RM
51.1	83	P
12.6	82	RL-UGB
1.6	97	STREET
67	83	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.62	Sheet Flow	0.24	200	0.01

		Length	Slope	Paved?
0.15	Shallow Overland	1200	0.02	n

		Length	Velocity
0.03	Length & Velocity	600	6

0.79 TOTAL (hours)

Sub-Basin N14

Area	CN	Description
4.8	88	P
16.7	84	RS
3.2	97	STREET
24.7	86	Sub-Basin Total

		'n'	Length	Slope
0.24	Sheet Flow	0.15	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.07	Length & Velocity	1600	6

0.35 TOTAL (hours)

Mt. Angel Storm Drain Master Plan
JO 447.5030.0
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BASIN CHARACTERISTICS - EXISTING CONDITIONS
SOUTH BASIN

2-yr 24 hr Rainfall 2.5 inches

Sub-Basin S1

Area	CN	Description
14.8	82	RL-UGB
1.4	83	RS
16.2	82	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.62	Sheet Flow	0.24	200	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	n

		Length	Velocity
0.00	Length & Velocity	0	2

0.65 TOTAL (hours)

Sub-Basin S2

Area	CN	Description
20.7	82	RL-UGB
14.1	83	RM
1.2	82	RS
1.6	88	STREET
0.4	91	P
6.1	97	
44.1	85	Sub-Basin Total

		'n'	Length	Slope
0.62	Sheet Flow	0.24	200	0.01

		Length	Slope	Paved?
0.12	Shallow Overland	1000	0.02	n

		Length	Velocity
0.00	Length & Velocity	0	6

0.74 TOTAL (hours)

Sub-Basin S3

Area	CN	Description
4.3	82	RL-UGB
14.5	83	RS
2.9	84	RM
3.4	82	P
0.2	82	EFU
3	97	STREET
28.3	84	Sub-Basin Total

		'n'	Length	Slope
0.62	Sheet Flow	0.24	200	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	n

		Length	Velocity
0.07	Length & Velocity	1000	4

0.72 TOTAL (hours)

Sub-Basin S4

Area	CN	Description
1.6	84	RM
4.3	92	CG
2	91	I
11.3	88	P
6.1	97	STREET
25.3	91	Sub-Basin Total

		'n'	Length	Slope
0.15	Sheet Flow	0.08	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.05	Length & Velocity	1000	6

0.22 TOTAL (hours)

Mt. Angel Storm Drain Master Plan
JO 447.5030.0
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BASIN CHARACTERISTICS - EXISTING CONDITIONS
SOUTH BASIN

2-yr 24 hr Rainfall 2.5 inches

Sub-Basin S5

Area	CN	Description
7.1	94	CG
0.5	94	P
1.7	91	I
7.8	97	STREET
17.1	95	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.10	Sheet Flow	0.05	100	0.01

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.06	Length & Velocity	1200	6

0.18 TOTAL (hours)

Sub-Basin S6

Area	CN	Description
19.9	83	I
0.6	91	I-UGB
1.3	94	RS
2	91	STREET
0.7	91	
4.7	91	
3.4	97	
32.6	87	Sub-Basin Total

		'n'	Length	Slope
0.42	Sheet Flow	0.15	200	0.01

		Length	Slope	Paved?
0.10	Shallow Overland	600	0.01	n

		Length	Velocity
0.02	Length & Velocity	300	4

0.55 TOTAL (hours)

Sub-Basin S7

Area	CN	Description
16	82	RS
0.2	91	P
1.2	97	STREET
17.4	83	Sub-Basin Total

		'n'	Length	Slope
0.37	Sheet Flow	0.24	150	0.02

		Length	Slope	Paved?
0.07	Shallow Overland	600	0.02	n

		Length	Velocity
0.03	Length & Velocity	400	4

0.47 TOTAL (hours)

Sub-Basin S8

Area	CN	Description
31.5	83	RS
3.7	80	P
1.8	80	I-UGB
8.9	97	STREET
45.9	85	Sub-Basin Total

		'n'	Length	Slope
0.27	Sheet Flow	0.24	100	0.02

		Length	Slope	Paved?
0.03	Shallow Overland	200	0.01	y

		Length	Velocity
0.07	Length & Velocity	1500	6

0.37 TOTAL (hours)

Mt. Angel Storm Drain Master Plan
JO 447.5030.0
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BASIN CHARACTERISTICS - EXISTING CONDITIONS
SOUTH BASIN

2-yr 24 hr Rainfall 2.5 inches

	Area	CN	Description
Sub-Basin S9	12.7	83	RS
	2.8	80	P
	8.7	82	RL-UGB
	2.7	82	RM-UGB
	57.4	82	EFU
	5.3	97	STREET
	89.6	83	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.47	Sheet Flow	0.24	200	0.02

		Length	Slope	Paved?
0.18	Shallow Overland	1500	0.02	n

		Length	Velocity
0.04	Length & Velocity	600	4

0.69	TOTAL (hours)

Mt. Angel Storm Drain Master Plan
JO 447.5030.0
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BASIN CHARACTERISTICS - FUTURE CONDITIONS
SOUTH BASIN

2-yr 24 hr Rainfall 2.5 inches

	Area	CN	Description	Time of Concentration		'n' / Length / Slope	Length / Slope / Paved?	Length / Velocity
Sub-Basin S1	14.8	84	RL-UGB	0.36	Sheet Flow	0.24 / 100 / 0.01		
	1.4	84	RS					
				0.03	Shallow Overland		200 / 0.01 / n	
				0.02	Length & Velocity			400 / 6
	16.2	84	Sub-Basin Total	0.41	TOTAL (hours)			
Sub-Basin S2	20.7	84	RL-UGB	0.49	Sheet Flow	0.24 / 150 / 0.01		
	14.1	84	RM					
	1.2	82	RS					
	1.6	94	STREET	0.03	Shallow Overland		200 / 0.01 / y	
	0.4	91	P					
	6.1	97		0.06	Length & Velocity			1400 / 6
	44.1	86	Sub-Basin Total	0.58	TOTAL (hours)			
Sub-Basin S3	4.3	84	RL-UGB	0.49	Sheet Flow	0.24 / 150 / 0.01		
	14.5	84	RS					
	2.9	91	RM					
	3.4	82	P	0.03	Shallow Overland		200 / 0.01 / y	
	0.2	82	EFU					
	3	97	STREET					
				0.05	Length & Velocity			1000 / 6
	28.3	86	Sub-Basin Total	0.56	TOTAL (hours)			
Sub-Basin S4	1.6	91	RM	0.15	Sheet Flow	0.08 / 100 / 0.01		
	4.3	94	CG					
	2	91	I					
	11.3	88	P	0.03	Shallow Overland		200 / 0.01 / y	
	6.1	97	STREET					
				0.05	Length & Velocity			1000 / 6
	25.3	92	Sub-Basin Total	0.22	TOTAL (hours)			

Mt. Angel Storm Drain Master Plan
JO 447.5030.0
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BASIN CHARACTERISTICS - FUTURE CONDITIONS
SOUTH BASIN

2-yr 24 hr Rainfall 2.5 inches

	Area	CN	Description	Time of Concentration		'n' / Length / Slope	Length / Slope / Paved?	Length / Velocity
Sub-Basin S5	7.1	94	CG	0.10	Sheet Flow	0.05 / 100 / 0.01		
	0.5	94	P					
	1.7	91	I		Shallow Overland		200 / 0.01 / y	
	7.8	97	STREET	0.03				
				0.06	Length & Velocity			1200 / 6
	17.1	95	Sub-Basin Total	0.18	TOTAL (hours)			
Sub-Basin S6	19.9	84	I	0.24	Sheet Flow	0.15 / 100 / 0.01		
	0.6	91	I-UGB					
	1.3	94	RS		Shallow Overland		200 / 0.01 / y	
	2	91	STREET	0.03				
	0.7	91						
	4.7	91		0.06	Length & Velocity			1200 / 6
	3.4	97						
	32.6	87	Sub-Basin Total	0.33	TOTAL (hours)			
Sub-Basin S7	16	84	RS	0.27	Sheet Flow	0.24 / 100 / 0.02		
	0.2	91	P					
	1.2	97	STREET		Shallow Overland		200 / 0.01 / y	
				0.03				
				0.03	Length & Velocity			600 / 6
	17.4	85	Sub-Basin Total	0.32	TOTAL (hours)			
Sub-Basin S8	31.5	84	RS	0.27	Sheet Flow	0.24 / 100 / 0.02		
	3.7	80	P					
	1.8	91	I-UGB		Shallow Overland		200 / 0.01 / y	
	8.9	97	STREET	0.03				
				0.07	Length & Velocity			1500 / 6
	45.9	86	Sub-Basin Total	0.37	TOTAL (hours)			

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BASIN CHARACTERISTICS - FUTURE CONDITIONS
SOUTH BASIN

2-yr 24 hr Rainfall 2.5 inches

Sub-Basin S9

Area	CN	Description
12.7	84	RS
2.8	80	P
8.7	84	RL-UGB
2.7	91	RM-UGB
57.4	82	EFU
5.3	97	STREET
89.6	84	Sub-Basin Total

Time of Concentration

		'n'	Length	Slope
0.47	Sheet Flow	0.24	200	0.02

		Length	Slope	Paved?
0.18	Shallow Overland	1500	0.02	n

		Length	Velocity
0.04	Length & Velocity	600	4

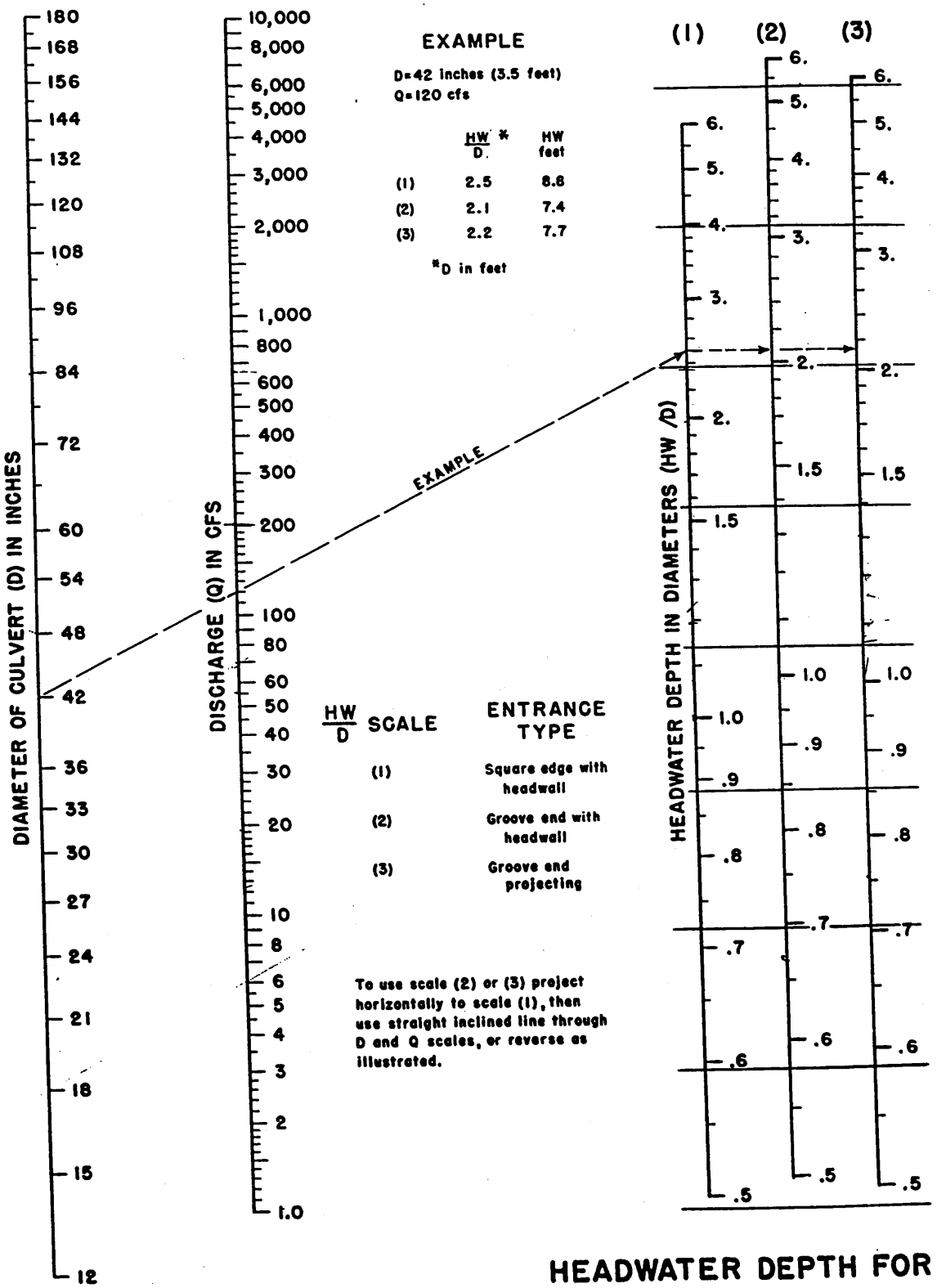
0.69	TOTAL (hours)

CITY OF MT. ANGEL
Storm Drainage System Master Plan

Sample Inlet Control and Outlet Control Nomographs

Appendix D

INLET CONTROL NOMOGRAPH 4.1.1

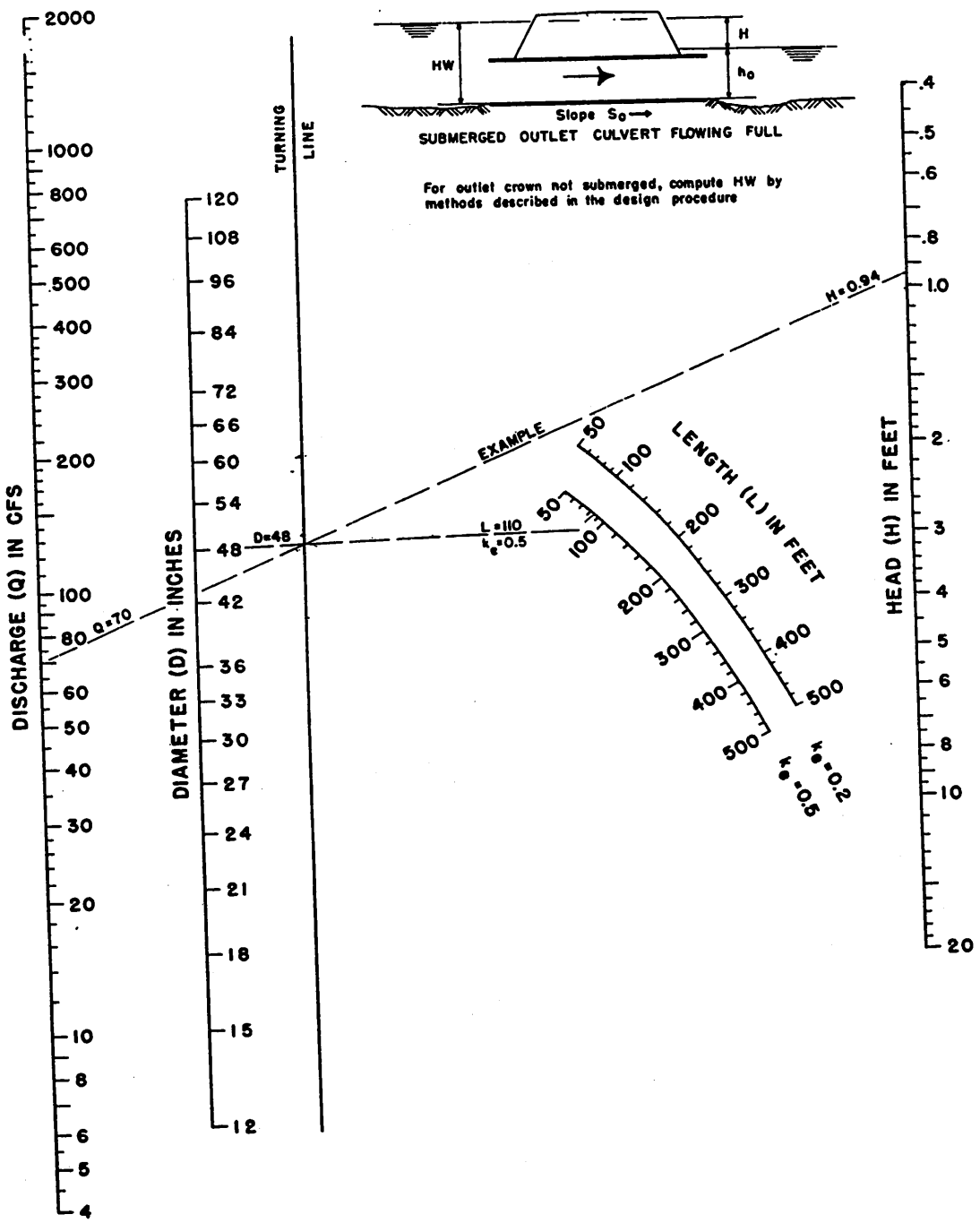


HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

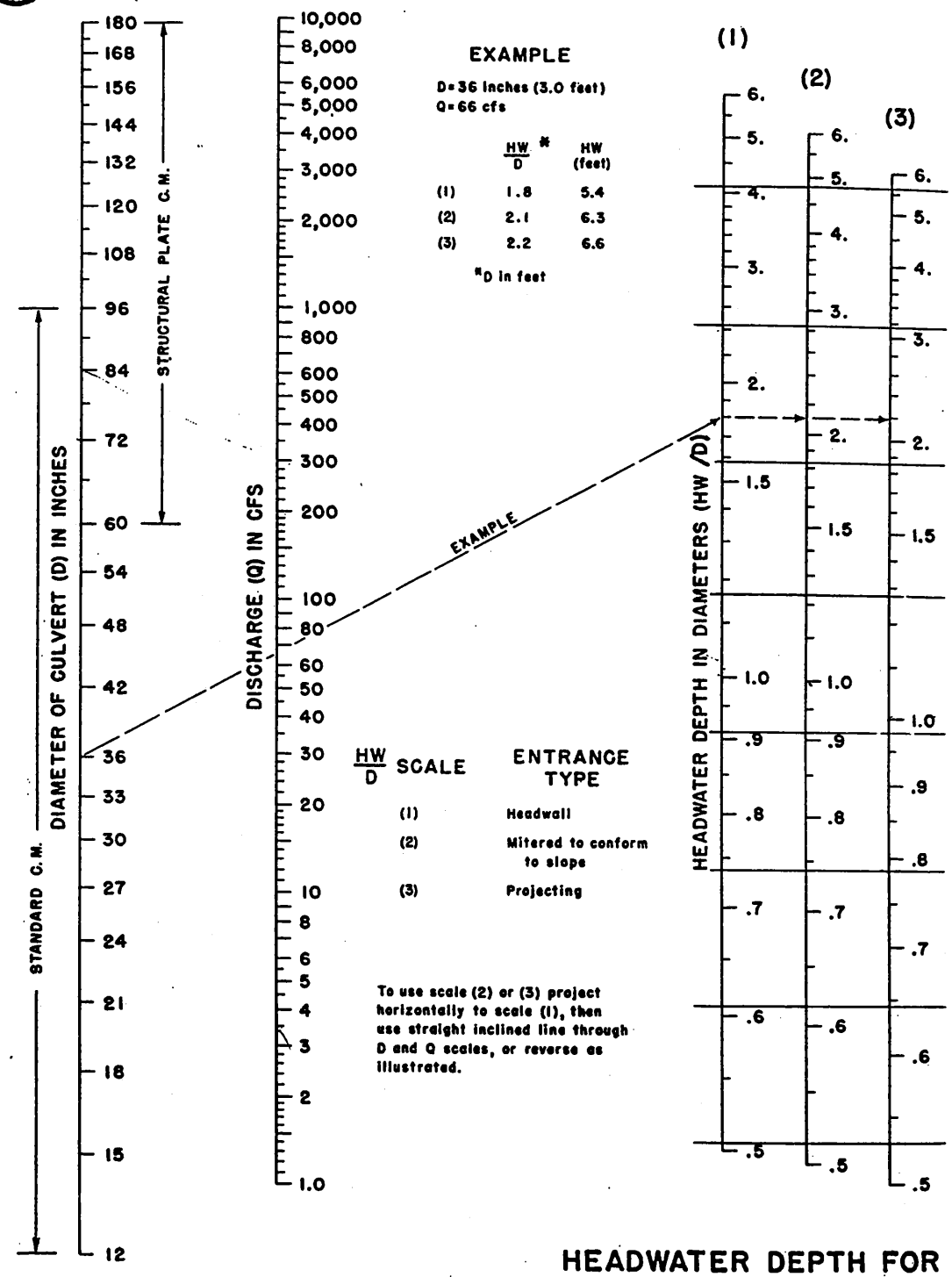
OUTLET CONTROL NOMOGRAPH 4.2.1



HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

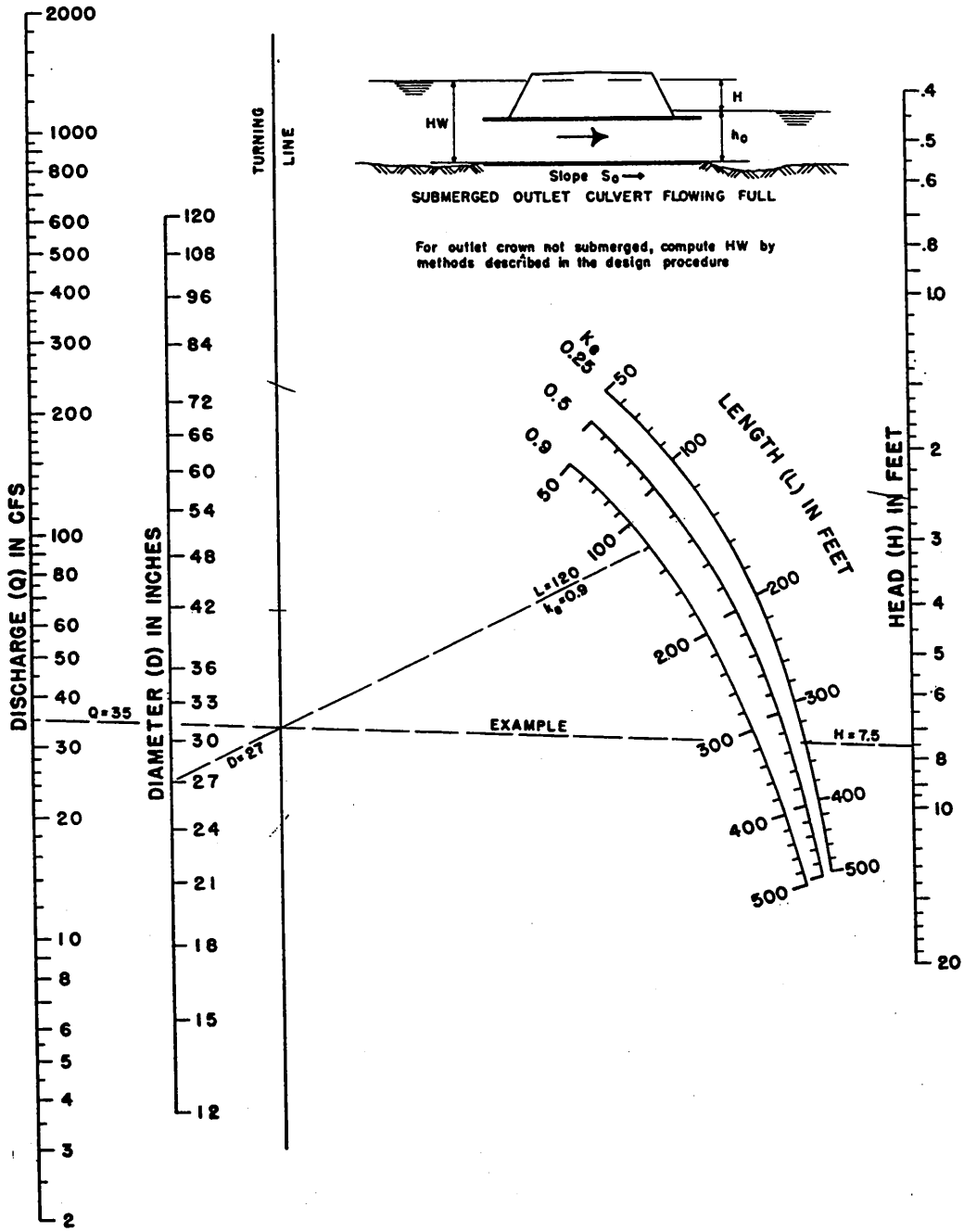
INLET CONTROL NOMOGRAPH 4.1.2



HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

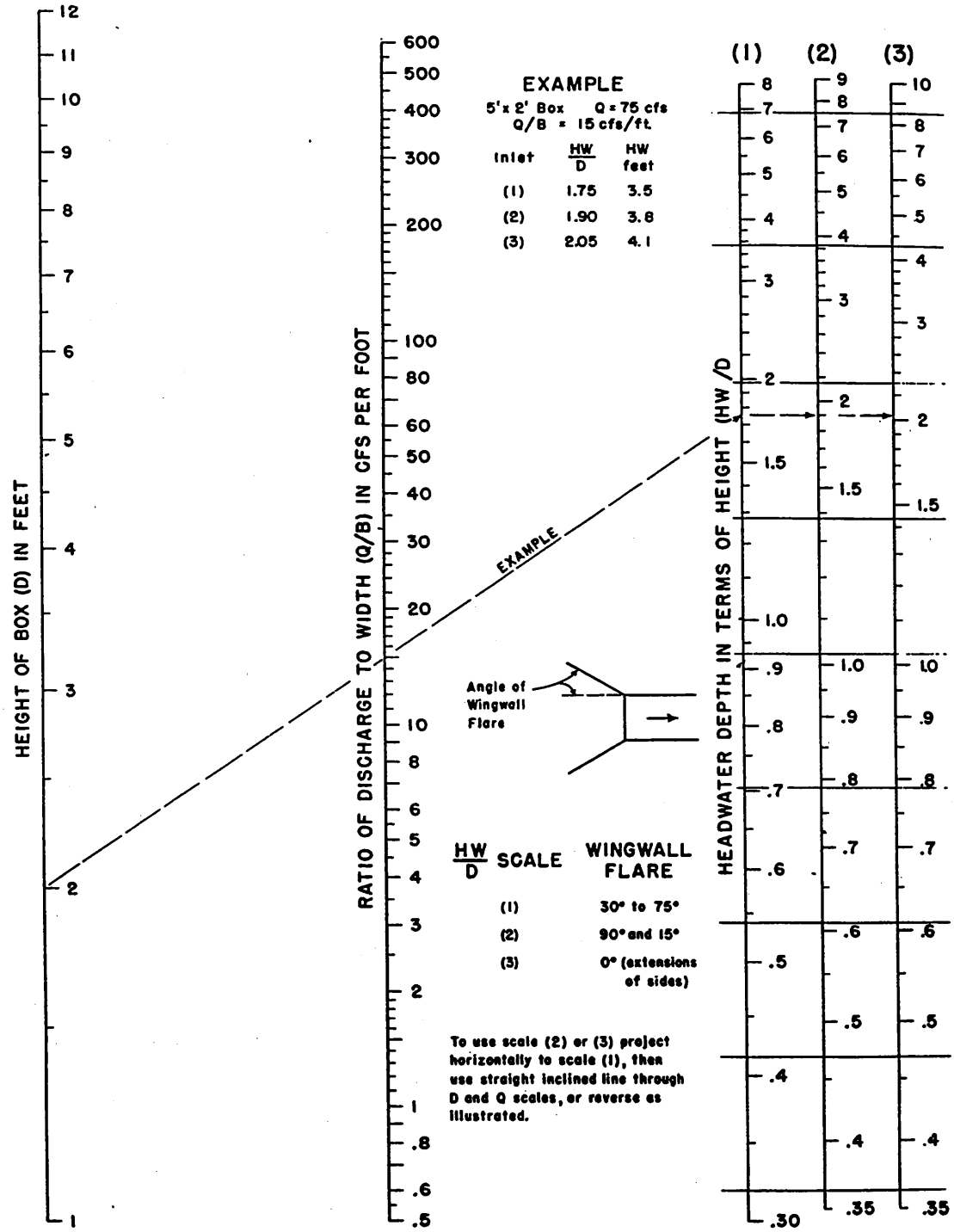
OUTLET CONTROL NOMOGRAPH 4.2.2



HEAD FOR STANDARD C. M. PIPE CULVERTS FLOWING FULL n = 0.024

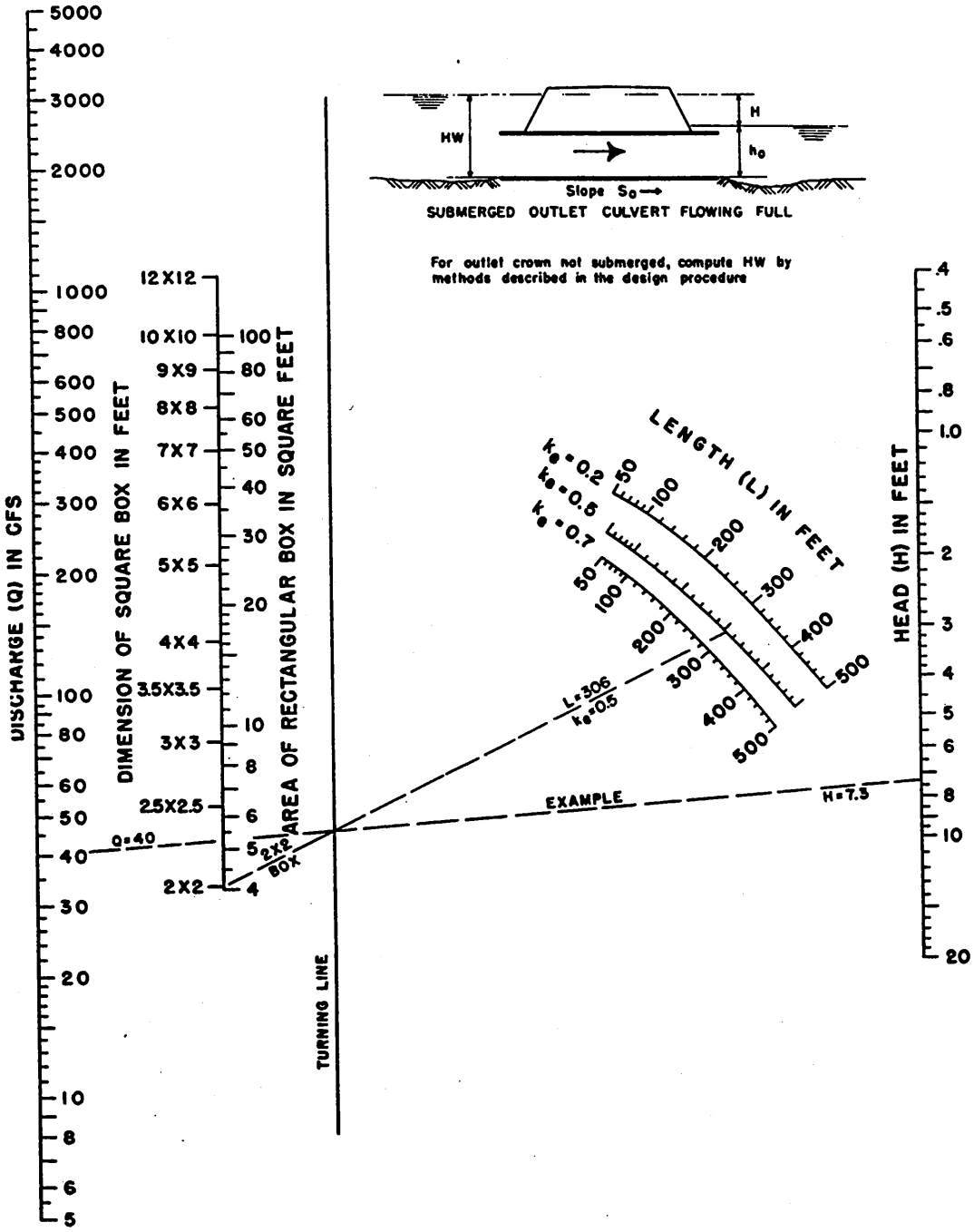
BUREAU OF PUBLIC ROADS JAN. 1963

INLET CONTROL NOMOGRAPH 4.1.4



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

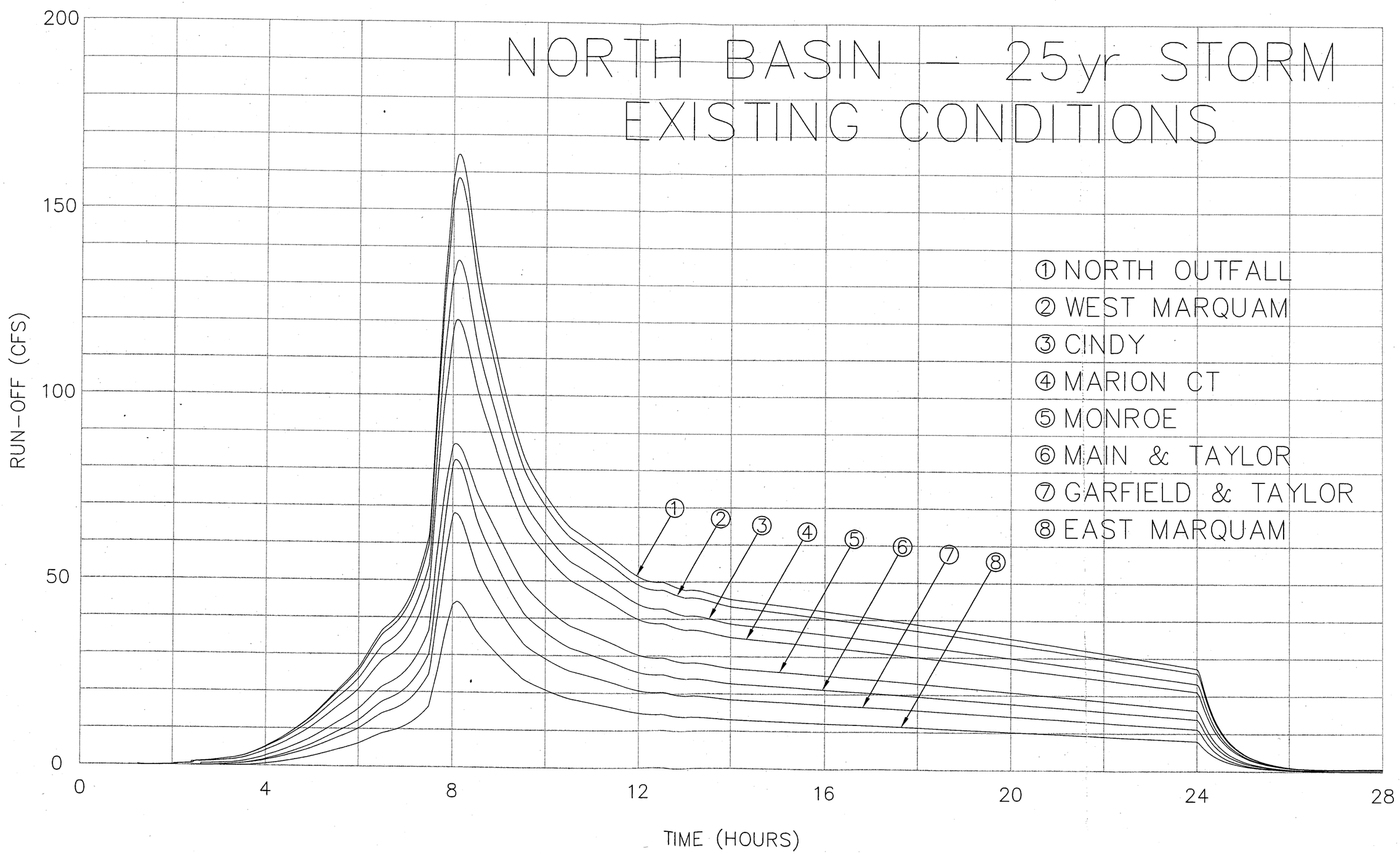


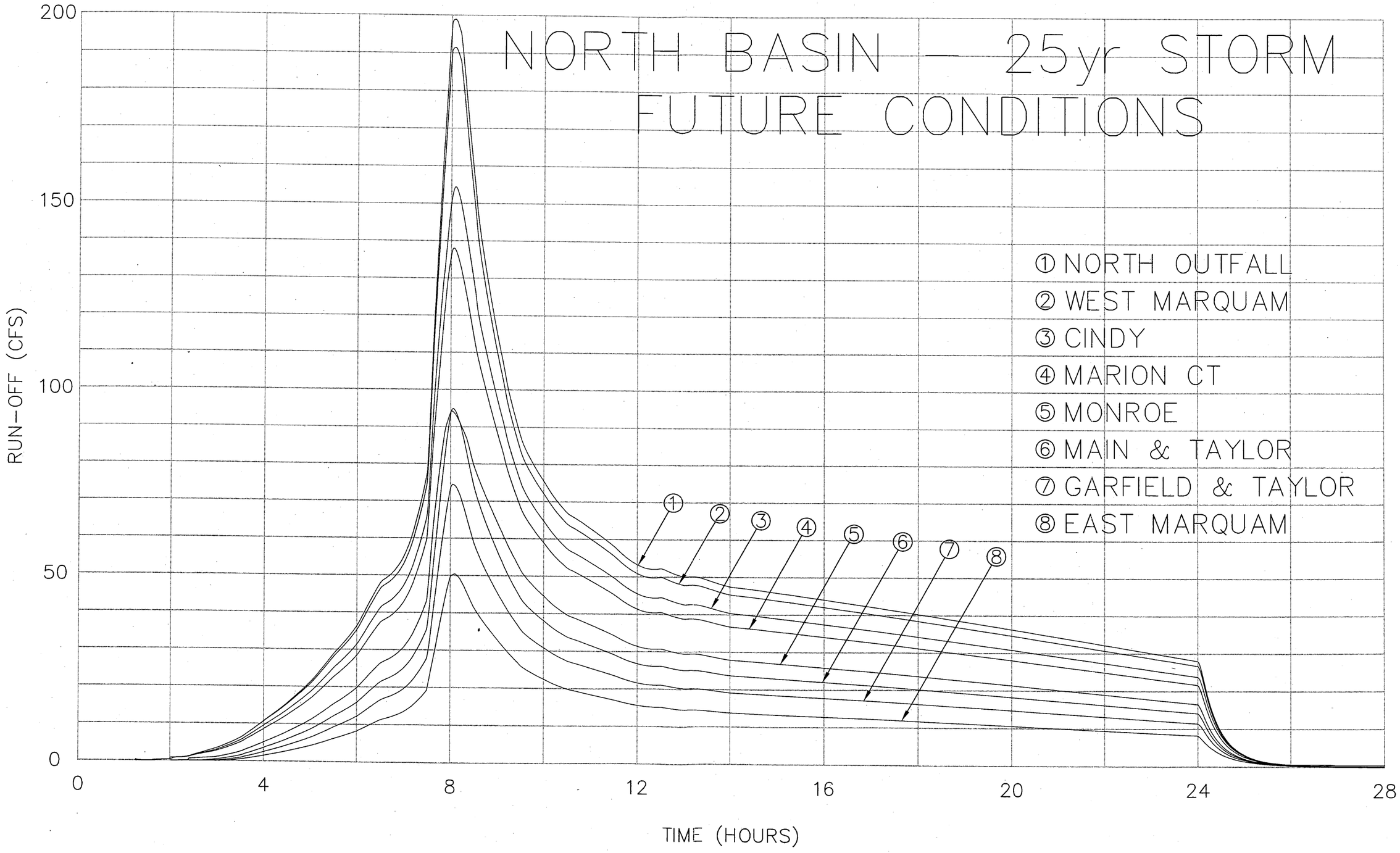
HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL
n = 0.012

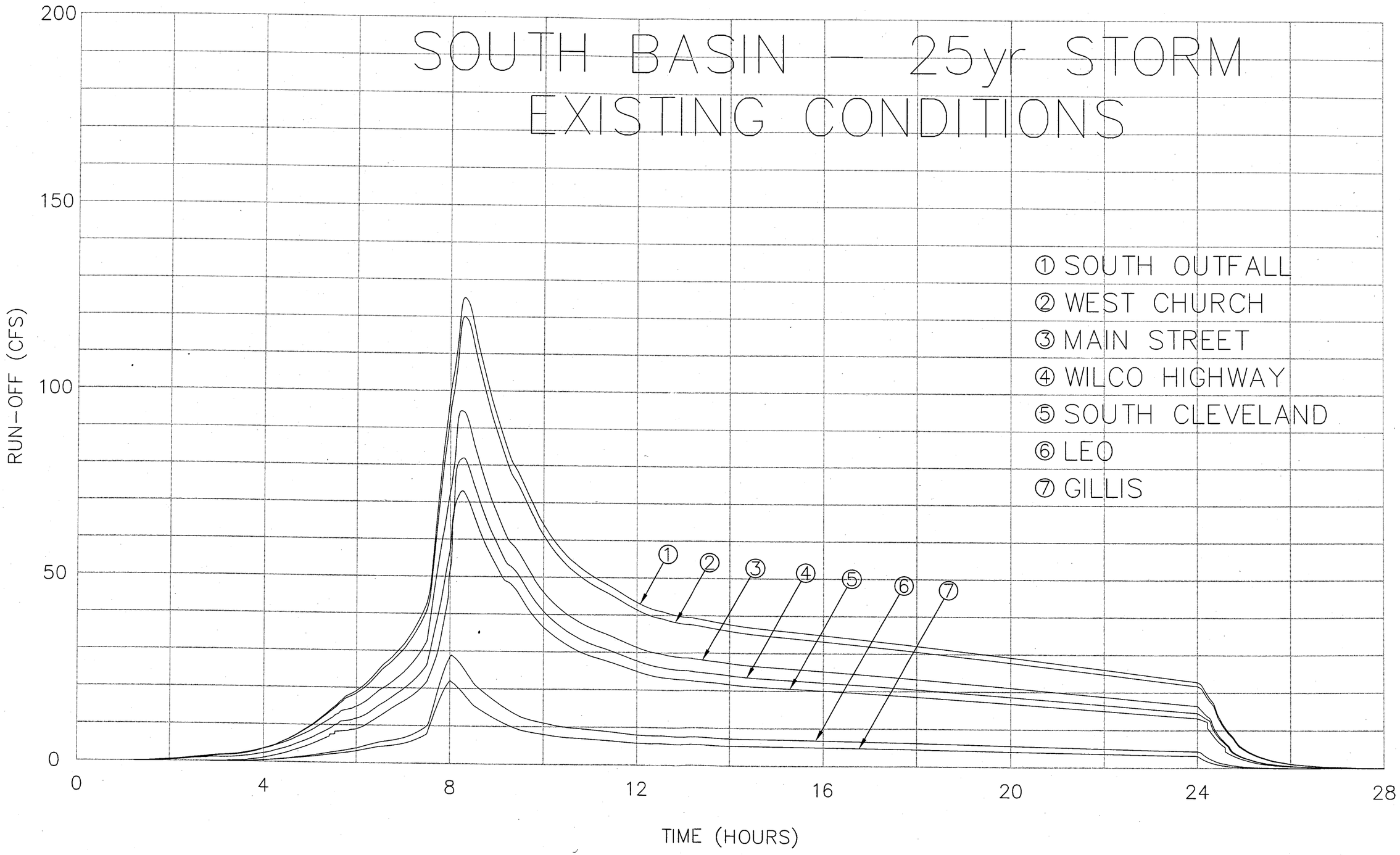
CITY OF MT. ANGEL
Storm Drainage System Master Plan

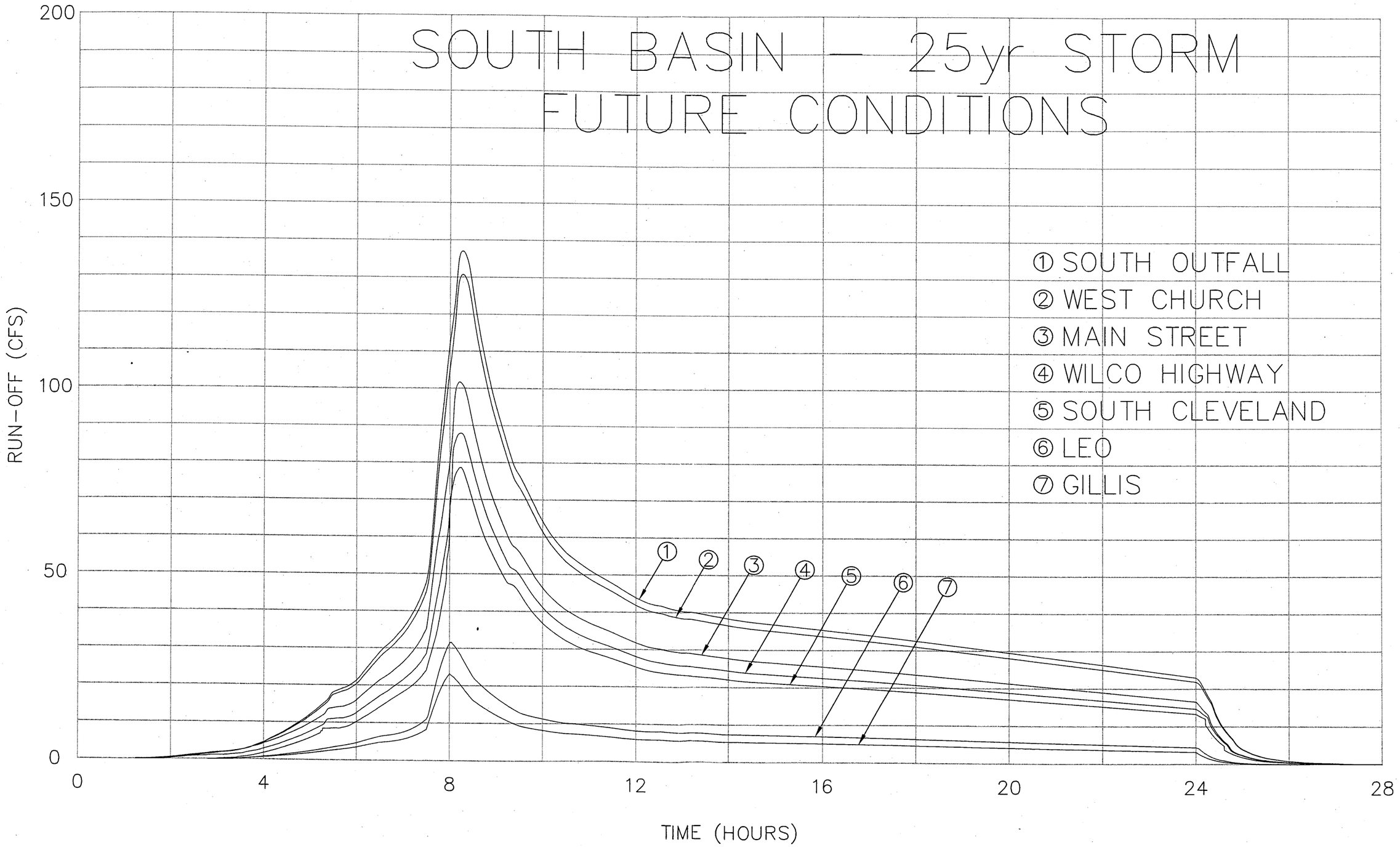
Santa Barbara Urban Hydrograph Plots

Appendix E


NORTH BASIN — 25yr STORM
EXISTING CONDITIONS
① NORTH OUTFALL
② WEST MARQUAM
③ CINDY
④ MARION CT
⑤ MONROE
⑥ MAIN & TAYLOR
⑦ GARFIELD & TAYLOR
⑧ EAST MARQUAM
RUN-OFF (CFS)
TIME (HOURS)
0
50
100
150
200
0
4
8
12
16
20
24
28


NORTH BASIN — 25yr STORM
FUTURE CONDITIONS
① NORTH OUTFALL
② WEST MARQUAM
③ CINDY
④ MARION CT
⑤ MONROE
⑥ MAIN & TAYLOR
⑦ GARFIELD & TAYLOR
⑧ EAST MARQUAM
RUN-OFF (CFS)
TIME (HOURS)
0
50
100
150
200
0
4
8
12
16
20
24
28


SOUTH BASIN — 25yr STORM
EXISTING CONDITIONS
① SOUTH OUTFALL
② WEST CHURCH
③ MAIN STREET
④ WILCO HIGHWAY
⑤ SOUTH CLEVELAND
⑥ LEO
⑦ GILLIS
RUN-OFF (CFS)
TIME (HOURS)
0
50
100
150
200
0
4
8
12
16
20
24
28


SOUTH BASIN — 25yr STORM
FUTURE CONDITIONS
① SOUTH OUTFALL
② WEST CHURCH
③ MAIN STREET
④ WILCO HIGHWAY
⑤ SOUTH CLEVELAND
⑥ LEO
⑦ GILLIS
RUN-OFF (CFS)
200
150
100
50
0
0
4
8
12
16
20
24
28
TIME (HOURS)

CITY OF MT. ANGEL
Storm Drainage System Master Plan

Sample (Draft) Stormwater Utility Ordinance

Appendix F

APPENDIX F - SAMPLE STORMWATER UTILITY ORDINANCE (DRAFT)

SAMPLE ONLY (DRAFT)

ORDINANCE NO. _____

AN ORDINANCE OF THE CITY OF HALSEY, OREGON, RELATING TO UTILITIES AND STORMWATER MANAGEMENT; AMENDING THE HALSEY MUNICIPAL CODE TO ADD A NEW CHAPTER ESTABLISHING A STORMWATER UTILITY; ADOPTING A SYSTEM AND PLAN FOR THAT UTILITY; AND AMENDING THE HALSEY MUNICIPAL CODE TO ADD A NEW CHAPTER COMBINING THE STORM WATER UTILITY WITH THE WATERWORKS UTILITY.

WHEREAS, the City Council of the City of Halsey (the "City') has determined that the City's physical growth and urban development has and will continue to increase the volume of stormwater runoff collected in and routed through the City's stormwater facilities and system ("stormwater system'); and

WHEREAS, the City Council finds that stormwater runoff causes property damage and erosion; carries concentrations of nutrients, heavy metals, oil and toxic materials into receiving waters and ground water; degrades the integrity of City streets and the transportation system; and reduces citizen access to emergency services and poses hazards to both lives and property; and

WHEREAS, the existing stormwater system in the City cannot adequately address runoff quantity or quality issues; and

WHEREAS, the City Council has determined that stormwater runoff must be managed in a manner that protects the public health, safety and welfare; and

WHEREAS, the City Council finds that stormwater quality and quantity problems cannot be allowed to escalate as a result of inadequate stormwater design criteria, regulation, public awareness or code enforcement; and

WHEREAS, after public meetings on the subject, the City Council finds that the City's stormwater system must be funded in a manner enabling comprehensive maintenance, operation and regulation of stormwater through revisions to the City's existing surface water service charge; and

WHEREAS, the City Council finds that all developed real property within the City's boundaries, contributes runoff to the City's stormwater system; that all developed real property benefits from the City's maintenance and operation of the stormwater system; and that all developed property should contribute to the funding of the City's program for maintenance, operation and improvement of the stormwater system; and

WHEREAS, a professional stormwater management and engineering consultant, and staff of the City's Public Works Department, have assessed methods for stormwater management, evaluated options for improvements and made appropriate recommendations;

APPENDIX F - SAMPLE STORMWATER UTILITY ORDINANCE (DRAFT)

NOW, THEREFORE,
THE CITY COUNCIL OF THE CITY OF HALSEY, OREGON DOES HEREBY ORDAIN AS FOLLOWS:

Section 1. A new chapter is added to the HALSEY Municipal Code, as follows:

CHAPTER_____

STORM WATER UTILITY

Purpose - Findings. The City finds and declares:

(1) All real property in the City contributes runoff to the common stormwater problem, and all real property in the City benefits from the stormwater utility of the City.

(2) The development of real property, as measured by the square footage of impervious surface area, is an appropriate basis for the determination of an individual parcel's contribution to the problem of stormwater runoff.

Potential Hazard Declared. The City finds and declares that absent effective maintenance, operation, regulation and control, existing stormwater drainage conditions in all drainage basins within the City constitute a potential hazard to the health, safety and general welfare of the City. The City Council further finds that natural and man-made stormwater facilities and conveyances together constitute a stormwater drainage system and that effective regulation and control of stormwater through formation, by the City, of a stormwater utility requires the transfer to the utility of all stormwater facilities and conveyances and related rights belonging to the City.

Stormwater Management Utility Created - Responsibilities. There is hereby created and established pursuant to Chapters _____ and _____ ORS, and Article , Section ___ of the Oregon State Constitution, a stormwater utility. All references to "the Utility" in this chapter refer to the stormwater utility. The Utility will have authority and responsibility for planning, design, construction, maintenance, administration and operation of all City stormwater conveyances and facilities.

Property Transferred to Utility. Title and all other incidents of ownership of the following assets are hereby transferred to and vested in the Utility: all properties, interests and physical and intangible rights of every nature owned or held by the City, however acquired, insofar as they relate to or concern stormwater, further including, without limitation, all properties, interests, and tights acquired by adverse possession or by prescription, directly or through another, in and to the drainage or storage, or both, of stormwater, through, under, or over lands, watercourses, sloughs, streams, ponds, lakes, and swamps, all beginning in each instance at a point where stormwater first enter the system of the City and ending in each instance at a point where the stormwater exits from the system of the City, and in width to the full extent of inundation caused by storm or flood conditions.

APPENDIX F - SAMPLE STORMWATER UTILITY ORDINANCE (DRAFT)

Utility Administered by Public Works Director. The Utility shall be administered by the Director of Public Works.

Section 2. A new chapter _____ is added to the HALSEY Municipal Code, as follows:

Chapter _____ COMBINED UTILITY

Combined Utility. The City is operating and maintaining a waterworks utility, consisting of a water and sewerage system. Pursuant to the provisions of ORS _____ the stormwater utility is hereby combined with the waterworks utility and, together with all additions, extensions and betterment thereof at any time made, shall hereinafter be called the "waterworks utility."

Waterworks Utility - Rates and Charges - Credit - Priority. In the event that any person, firm or corporation shall tender as payment of water, sewer, or stormwater services an amount insufficient to pay in full all of the charges so billed, credit shall be given first to the stormwater utility charges, second to the charges for sanitary sewer service and lastly to the charges for water service.

In the event that any utility account shall become delinquent, water service may be terminated by the City and discontinued until all delinquent rates or charges for the use of the stormwater service, sanitary sewer service and water service shall have been paid in full. The provisions for collection provided herein shall be in addition to any rights or remedies which the City may have under the laws of the State of Oregon.

Section 3. The Public Works Department shall prepare or cause to be prepared a comprehensive stormwater quantity and quality management plan for consideration by the City Council. This plan shall be presented to Council no later than _____ months after enactment of this stormwater utility ordinance.

Section 4. Any acts made consistent with the authority and prior to the effective date of this ordinance are hereby ratified and confirmed.

Section 5. This ordinance shall take effect and be in force five (5) days after its passage, approval and publication as provided by law.

INTRODUCED: Mayor

PASSED:

APPROVED AS TO FORM: ATTEST:

City Attorney
City Clerk Published: Effective:

ORDINANCE 1994-19

AN ORDINANCE AMENDING ORDINANCE 1983-2. AN ORDINANCE REGULATING THE USE OF PUBLIC AND PRIVATE SEWERS AND DRAINS.

NOW, THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF SHERIDAN, as follows:

Section 1: Ordinance 83-2 shall be amended to include the following:

ARTICLE X
STORM DRAINAGE CHARGE

A. A storm drainage fee shall be established. The obligation to pay the storm drainage fee arises when a person responsible uses storm drainage services. It is presumed that storm drainage services are used whenever there is an improved premises.

B. Unless another person responsible has agreed in writing to pay, and a copy of that writing is filed with the city, the person paying the city's utility charges shall pay the storm drainage fees. If there is no water service to the property or if water service is discontinued, the storm drainage fees shall be paid by the person having the right to occupy the property.

C. When establishing fees for storm drainage service the Council shall:

1. Establish a monthly rate for a single family unit, which rate shall be applied to residentially used property based upon the number of dwelling units, and which rate shall be the rate for an equivalent residential unit, and

2. Establish a monthly rate for all property not included in subsection C(1) of this section, based on the amount of the property's impervious surface.

a. For each three thousand square feet of impervious surface, as determined by the City Engineer, the said property will be charged the rate for a single family unit. The minimum service charge shall be that established for a single family unit.

b. The storm drainage fees for a mobile home park shall be established at the rate of one single family unit per space.

c. The maximum charge for a multiple-family building or facility shall be limited to the number of multiple family units on the property multiplied by the charge for a single family unit.

D. When required, area measurements may be determined from records of the county assessor or by the City Engineer.

E. A responsible person may apply for a reduction or elimination of the monthly charge for storm drainage service through submission of appropriate evidence to the City Engineer. The applicant must show to the Engineer's satisfaction that:

1. The square footage of impervious surface was miscalculated for the property; or

2. All storm water from the property is being discharged directly into the South Yamhill River and not into the City drainage system.

Any reduction or elimination given shall continue until the property is further developed or until the City Engineer determines the property no longer qualifies for the reduction or elimination granted. Upon further development of the property another application may be made by a person responsible. Any applicant aggrieved by the City Engineer's decision may appeal to the City Manager by filing a written request for review. This must be done no later than ten days after receiving the City Engineer's decision. The City Manager's decision shall be final.

F. The rate of a single family unit shall be established at $3.00 per month.

Section 2: The Council desires and deems it necessary for the preservation of the health, peace and safety of the City of Sheridan that this Ordinance take effect at once, and therefore, an emergency is hereby declared to exist, and this ordinance shall be in full force and effect from and after its passage and approval.

PASSED by the Council of the City of Sheridan this ____ day of _____, 1994, by the following vote:

AYES: _____

NAYS: _____

Approved by the Mayor this _____ day of _____, 1994

_____
Mayor

ATTEST:

_____
City Recorder

APPENDIX F - SAMPLE STORMWATER UTILITY ORDINANCE (DRAFT)

SAMPLE ONLY (DRAFT)

ORDINANCE NO. _____

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WHEREAS, the City Council finds that all developed real property within the City's boundaries, contributes runoff to the City's stormwater system; that all developed real property benefits from the City's maintenance and operation of the stormwater system; and that all developed property should contribute to the funding of the City's program for maintenance, operation and improvement of the stormwater system; and

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Section 5. This ordinance shall take effect and be in force five (5) days after its passage, approval and publication as provided by law.

INTRODUCED: Mayor

PASSED:

APPROVED AS TO FORM: ATTEST:

City Attorney
City Clerk Published: Effective:

ORDINANCE 1994-19

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PASSED by the Council of the City of Sheridan this ____ day of _____, 1994, by the following vote:

AYES: _____

NAYS: _____

Approved by the Mayor this _____ day of _____, 1994

_____
Mayor

ATTEST:

_____
City Recorder