HYDROLOGIC STUDY OF SOUTH END BASIN

SOUTH END BASIN MASTER PLAN

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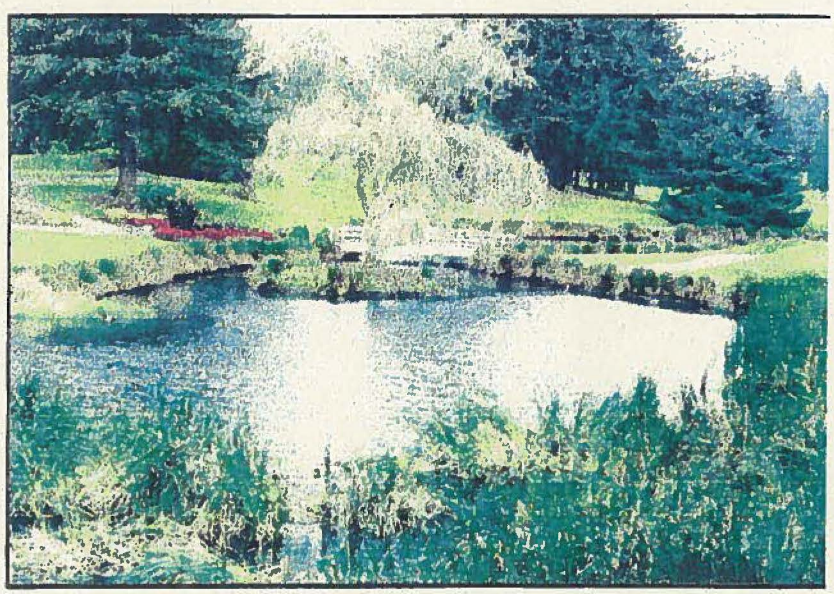
(By Ordinance 97-1010)



Prepared for:

City of Oregon City
and
Clackamas County
Community Development Division

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INTRODUCTION

Background and Authorization

The City of Oregon City and Clackamas County are currently planning for future development within a drainage basin, approximately 607 acres in size, located along South End Road, south of Warner Parrott Road, and northwesterly from Central Point Road, herein called the South End Drainage Basin. **Kampe Associates, Inc. (KAI)** has been retained to perform the following professional services:

1. Contact public agencies to determine agency requirements and any problems known to the agency.
2. Review existing conditions and available documents pertinent to the project.
3. Prepare a Master Storm Drainage Plan for the basin, based upon the above information.
4. Conduct a public involvement process, which includes, at a minimum, presentation of the final plans to the City Commission at a work session, and presentation of the plans for discussion and approval by the City Planning Commission.
5. Prepare and print thirty copies of the plan and provide them to the City.

Purpose and Objectives

In order for the City of Oregon City (City) to provide storm drainage facilities that will meet the needs of future development, a plan must be prepared to identify and model the basin-wide drainage system, considering both the existing facilities and future build-out. Urbanization of a watershed changes its response to precipitation. Development typically increases the amount of impervious area, increasing both the peak runoff flow rate and total runoff volume, and decreasing the time of concentration. As development occurs, this increased runoff may result in flooding, water quality degradation, erosion and sedimentation. The purpose of this drainage plan is to develop both the short-term stormwater needs and the long-term storm water management goals of the basin.

In 1988, a Storm Drainage Master Plan was developed for all of Oregon City, including some areas within unincorporated Clackamas County. This Master Plan presented a capital improvement program designed to solve the then existing major drainage problems and provide adequate drainage facilities for the study area under ultimate planned development conditions. In addition, it presented design standards for storm drainage, and funding methods to complete the recommended improvements.

The South End Drainage Basin was recently identified by the City and County for further study. It is our understanding that it was selected due to periodic flooding problems resulting from inadequate conveyance facilities, and because significant development is anticipated in the future. The objectives of this study are:

- To analyze the existing drainage system, verifying the modeled flow rates from the 1988 study, and adjusting for recent construction.
- Determine a layout for the primary "backbone" drainage system. The recommendations for this backbone system will be used as a guide for future development, ensuring that development proposals incorporate these recommended drainage facilities. In addition, the plan may be used to schedule capital improvements in areas not expected to develop or redevelop.

STUDY AREA CHARACTERISTICS

Geography and Topography

Within this basin of rolling uplands, the principal stream channel, herein called South End Creek, flows from north to south, with side drainage entering the main stream. The main channel of South End Creek crosses South End Road between Salmonberry Drive and Forest Ridge Lane. South End Road is primarily not curbed, and crosses the basin from northeast to southwest. The basin is relatively flat, collecting concentrated stormwater runoff in roadside ditches and broad grassy swales.

Climate/Rainfall Pattern

Climatological data from the National Oceanic and Atmospheric Administration (NOAA) was reviewed for the Oregon City reporting station. The City of Oregon City has mild, wet winters and warm, relatively dry summers. Average minimum winter temperatures are in the mid-thirties, with extremes seldom dropping below zero degrees Fahrenheit. Average maximum summer temperatures are in the low eighties, with extremes seldom exceeding one hundred degrees Fahrenheit. The average annual precipitation is approximately forty-seven inches, with much of the precipitation occurring from October to May. Snowfall constitutes less than two percent of the annual precipitation.

Drainage Problems

Oaktree Subdivision was built in a natural "saddle" between the South End Basin to the south and the Amanda Court Basin to the north. This relatively flat area receives sheet and piped drainage from both east and west sides of the "saddle." The storm drainage piping, constructed as a part of Oak Tree Subdivision, however, is relatively shallow, receiving only part of the area sheet drainage and only the piped drainage from the east; (the westerly drainage pipe from Lafayette Avenue flows into this area). This results in areas of standing water during and after storm events, having no outlet to a piped drainage system. Consequently, residential yards and basements along the northeasterly side of Oak Tree Avenue, between Cook Street and Lafayette Avenue have chronic flooding problems.

South End Creek reaches South End Road opposite McLoughlin Elementary School. In 1993, Clackamas County Department of Transportation and Development made storm drainage improvements along the west side of South End Road, from just north of the School parcel to just south of South End Court. This project installed 18-inch and 42-inch diameter concrete pipes and catch basins in the previous roadside ditch alignment. These improvements were initiated to improve pedestrian access in the School vicinity, while providing adequate stormwater flow capacity, as outlined in the 1988 Master Plan. Downstream from this improvement, the existing roadside ditch has deficiencies needing attention. The channel is approximately four feet deep, with steep side slopes, making maintenance difficult. It is currently choked with vegetation. The culvert outfall at South End Court has eroded the roadway shoulder, causing sections of asphalt to collapse into the ditch. The depth of this ditch, and the narrow shoulder width in this area, create the same pedestrian safety issues which prompted the upstream improvements.

FEMA Flood Data

As noted in the 1988 Master Plan, the most recent Flood Insurance Study (FIS) was published by the Federal Emergency Management Agency (FEMA) in 1977. For the purpose of both insurance and regulation of development within the floodplain, FEMA established the 100-year flood as the base, or regulatory, flood. The 100-year flood event, by definition, has a one percent chance of occurrence in any given year. The FIS maps show no flooding hazard in the South End Basin during this 100-year flood event. Since localized flooding problems are known to exist, it is assumed that the 1977 FEMA study made no analysis of this (then largely rural) area.

Soils Characteristics

Classification of soils in the study area has been made by the Soil Conservation Service; (see **Exhibit 1** for a map of the soil types in the study area). Soils are categorized into *Hydrologic Soil Groups*, based on an estimate of the amount of runoff resulting from precipitation. These groupings assume that the soils are thoroughly wet and receive precipitation from long-duration storms. This rainfall to runoff relationship is complex and includes the *drainage* and *permeability* characteristics of the soil.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock, to a cemented pan, or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and potential frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock or to a cemented pan, large stones, slope, and the hazard of cutbanks caving.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior. Typical soil permeabilities vary from low values between 0.2-0.6 inches/hour to moderate values between 0.6-2.0 inches/hour to high values between 2.0-6.0 inches/hour.

The four hydrologic soil groups are:
Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained t excessively drained sands or gravelly sands. These soils have a high rate of water transmission.
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Soils in the study area are predominately silt loams on level to moderate slopes. Drainage characteristics for these soils, with the exception of the area of Delena Silt Loam, are moderate. Table 1 summarizes the various soil types found and their hydrologic grouping.

TABLE 1 HYDROLOGIC GROUPINGS OF SOILS		
Soil Legend	Soil Name	Hydrologic Soil Group
8B	Bornstedt Silt Loam, 0-8% slopes	C
24B	Cotrell Silty Clay Loam, 2-8% slopes	C
30C	Delena Silt Loam, 3-12% slopes	D
46B	Jory Stony Silt Loam, 3-8% slopes	C
46C	Jory Stony Silt Loam, 8-15% slopes	C
64B	Nekia Silty Clay Loam, 2-8% slopes	C
Source: Soil Survey of Clackamas County, Oregon (U.S. - SCS)		

Existing Drainage Facilities

The existing storm drainage facilities consist primarily of roadside ditches, culverts and open channels, with two exceptions: storm drains constructed with the Partlow Estates and Cook Street Addition Subdivisions; and "Minor" storm drainage systems, discharging into drainage swales in open space areas, constructed with the older rural subdivisions listed above. (Map of the existing facilities is included as **Exhibit 2**.)

Land Use

The transition of a drainage basin from rural to urban land uses can greatly alter its hydrological response to rainfall. Urban land development is usually characterized by a rapid conversion from farmland and natural vegetative cover to rooftops and pavement. This increase in impervious land surfaces can dramatically alter the quantity and quality of storm runoff. As urban development occurs, the amount of rainfall converted to surface runoff is increased and the amount of rainfall contributed to groundwater recharge is decreased. If urban development is accompanied by an efficient drainage system, the time needed for surface runoff to reach a stream is substantially decreased. This results in a concentration of stormwater runoff that generally increases peak flow. Greater peak flows can create flooding problems, depending on the capacity of the drainage system and the downstream conditions.

This basin has developed primarily a low-density (approximately two lots per acre), single-family residential homes, while under the jurisdiction of Clackamas County. More recently, "Cook Street Addition," "Westling Farm," Hazelgrove" and "Partlow Estates" subdivisions have developed with higher density (approximately five lots per acre). The following subdivisions are located within the basin:

Asquith Estates
Cook Street Addition
Finnegans Terrace 1,2, &3
Longstanding Acres
Hazelgrove 1 & 2
Oaktree
Oregon City Maywood Park
Navajo Hills Estates
Partlow Estates
South End Terrace
South Park Estates
Sunview Acres
Sunnyridge Acres 1,2, &3
Westling Farm
Willaview

Wetlands

All developers and agencies must consider wetlands issues from the outset of a project and determine whether sites considered for construction contain a "jurisdictional" wetland. A jurisdictional wetland has been defined under Section 404 of the Clean Water Act as "Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Wetlands falling within this definition are subject to regulation under the Clean Water Act. The "Federal Manual for Identifying and Delineating Jurisdictional Wetlands" provides identification procedures based on the presence of hydrophytic vegetation, hydric soils and wetland hydrology. In Oregon, an application for authorization to alter a wetland under the respective state and federal programs requires a joint filing submitted to the Oregon Division of State Lands (ODSL) and the U.S. Army Corps of Engineers (COE). A permit is required for any activity that proposes to remove, fill or alter more than fifty cubic yards of material within the bed or banks of "waters of the State of Oregon." These agencies determine if the proposed project meets regulations and require mitigation of impacts (typically creation of a new wetland, or enhancement of an existing wetland), so that the area has no net loss in wetland values. A "Nationwide Permit" program issues permits for projects falling under general categories having minimal impact, such as maintenance activities, pipeline crossings and outfall structures. Failure to comply with state or federal wetland regulatory requirements can be costly.

In addition to COE and DSL requirements, the Oregon Department of Environmental Quality (DEQ) has the responsibility, under Section 401 of the Clean Water Act, to insure that all permitted activities meet state water quality standards. Finally, local jurisdictions in Oregon are required, under Oregon's Land Use Planning Goals, to implement programs to meet specific goals. Goal 5, Open Spaces, Scenic and Historic Areas, and Natural Resources, is "to conserve open space and protect natural and scenic resources." Wetlands are one of the natural resource types identified in the Goal. Local jurisdictions in Oregon are in various stages of compliance with Goal 5. In 1993, the City of Oregon City conducted a wetland inventory, as a first step in meeting this Goal. Two areas within the South End Basin were identified in this inventory as having resource value:

- The area of Delena (SCS group D) Soils along Rose Road (see **Exhibit 1**).
- The ponds along Parrish Road, near the downstream end of the basin.

Only the latter (Parrish Road ponds) are currently listed and mapped in the National Wetlands Inventory (NWI) database, being identified as jurisdictional wetlands. The City, in the 1993 study, has noted this as an area having high resource value that should be protected and recommends a detailed wetland analysis.

The City has also, in implementing Goal 5, adopted into its Municipal Code a Water Resources (WR) Overlay District, intended to protect water resource areas, both ponds and water courses. A "transition area" extending fifty feet from the boundary of the water area or water course is included in the managed area of each water resource area. Since these requirements apply only to those water resources identified in the water resource inventory of the City and County, the agencies should evaluate this inventory, based on the areas identified in this Report, which are proposed to remain as open channel drainage courses.

MODELING AND DESIGN METHODOLOGY

Data Collection

In cooperation with the City and County, **Kampe Associates, Inc. (KAI)** collected available data relative to the drainage characteristics of the study area. Data included mapping and "as-built" drawings of the existing drainage facilities, rainfall information, soil types, existing and proposed land use, and wetlands. Existing information was verified, wherever possible, by field visits to the site. For the preparation of the base map, digital topographic information, created from aerial photogrammetry using orthophoto base maps (created in 1987 by Spencer B. Gross Engineering), was obtained for the study area. This topographic information is plotted with two-foot contour intervals and includes spot elevations.

For this study, record drawings were obtained from the City of Oregon City for existing drainage facilities; and field investigations were made to verify, and add to, the record information. Geographic Information System (GIS) information was obtained from the City of Portland Metropolitan Service District (METRO) Planning Department, including soil types, parcel boundaries, wetlands and urban growth boundary within the South End Drainage Basin. Design drawings of the Cook Street Addition and Partlow Estates Subdivisions were obtained from City records. This information was added to the topographic base information to create a composite base map for report exhibits, and for use in performing the hydrologic analysis

Land Use Model

Land covers are especially important in hydrology. For existing conditions, the base maps were used to measure the current impervious area percentages. For ultimate planned development conditions, the 1988 Drainage Master Plan was used to determine impervious area percentages, with modifications based on specific anticipated "ultimate" build out conditions. Areas designated as "Rural Residential" are currently developed and, as described above, were assumed to double in density of housing at ultimate development. Areas designated "Low Density Residential" were assumed to be developed at five units per acre at ultimate development. Areas designated "School" were assumed to be unchanged at ultimate development. (**Exhibit 3** shows the land use designations used for modeling.)

Watershed Model

The South End Drainage Basin was divided into eight subbasins for this Analysis. These subbasins correspond to the 1988 Master Plan locations, with boundaries adjusted to perform a more detailed analysis and to reflect current stormwater flow patterns (see **Exhibit 4**). A computer program was used to create a hydrologic model to analyze the existing drainage subbasins. The computer program used in the analysis was the Watershed Modeling program developed by the Eagle Point Corporation. The Watershed Modeling program can perform multiple watershed modeling tasks, such as rainfall hyetograph synthesis, flood hydrograph synthesis, flood routing analysis, and storage routing, using a variety of computational modeling methods. The methods utilized in this study are described below.

Storm Recurrence Interval

In designing storm drainage facilities, it is common practice to size culverts, pipes and ditches for larger flows in areas that cannot tolerate flooding (such as major highways) and to size for smaller flows in less-traveled areas (such as local collector streets), which can tolerate a greater amount of flooding. This is a matter of economics relating to the storm recurrence interval. If hydraulic facilities are designed for a 100-year storm recurrence interval, the probability that the design flow will be exceeded in any given year is quite low (i.e., one percent probability), so the level of protection against flooding would be very high. If the design was based on a 2-year storm recurrence interval, the probability of exceedance would be very high (i.e., fifty percent probability in any given year), so the level of protection would be quite low. The obvious tradeoff in the planning and design of drainage facilities is the cost of the facility. The 25-year storm recurrence interval was chosen as the maximum storm event to consider for "minor" drainage structures and for detention analysis, and the 100-year storm recurrence interval was chosen as the design storm event for the "major" channel analysis of the South End Drainage Basin.

Rainfall

Runoff volume is determined primarily by the amount of precipitation and by infiltration characteristics related to soil type, antecedent moisture, type of vegetal cover, impervious surface and surface retention. Once the storm recurrence interval or design frequency has been established, the rainfall intensity can be determined. This study uses the Intensity-Duration-Frequency (IDF) curve prepared for the Oregon City region in Metro's 1980 "Storm Water Management Design Manual." (The original IDF curve and interpolated data points used for modeling are included in Appendix "A".)

For purposes of hydrologic analysis and design, the rainfall distribution with respect to time, or hyetograph, is required. A hyetograph can be synthesized, if a series of rainfall distribution values are known. The United States Soil Conservation Service (SCS) developed dimensionless rainfall distributions, based on the generalized rainfall-duration-frequency relationships established by the U.S. Weather Bureau. An SCS Type 1A rainfall distribution was used in this study. The 1A rainfall distribution was found by the SCS to be applicable to the storm patterns observed in the portion of Oregon and Washington located west of the Cascades. Appendix B presents the SCS rainfall distribution regions for the Pacific states and a graph of the Type 1A rainfall distribution.

Using the SCS rainfall distribution charts, the total precipitation for the 2-year, 25-year, and 100-year storm recurrence intervals were estimated to be as follows:

2-Year, 24-Hour Storm	2.6 Inches
25-Year, 24-Hour Storm	4.0 Inches
100-Year, 24-Hour Storm	4.5 Inches

The total precipitation values listed above were input into the Watershed Modeling program to synthesize the rainfall hyetographs. From the hyetographs, storm runoff hydrographs (time distributions of storm runoff) were created by the program. From the hydrograph, peak runoff values and total volumes over time were found.

SCS Curve Number Method

The Watershed Modeling computer model offers the user many options in the method used to transform rainfall input into rainfall excess. (Rainfall excess is the portion of rainfall that does not infiltrate into the soil-cover complex and is, therefore, available for runoff.) The SCS's Curve Number method was selected for use in this study. In this method, the combination of hydrologic soil group and land use is used to determine the hydrologic soil-cover complex. The effect of the hydrologic soil-cover complex on the amount of rainfall that runs off is represented by a runoff curve number, referred to as CN. The curve numbers assigned to each of the land use areas in the study area are shown in Table 2. Soil types within the South End Basin are within hydrologic soil groups C and D (see Table 2).

TABLE 2 CURVE NUMBERS USED FOR HYDROLOGIC SOIL GROUPS WITHIN THE SOUTH END DRAINAGE BASIN				
Land Use Description	**Curve Numbers for Hydrologic Soil Group**			
	A	**B**	**C**	**D**
Low Density Residential (LDR)	N/A	N/A	90	N/A
Rural Residential (RUR)	N/A	N/A	82	N/A
Schools (SCH)	N/A	N/A	74	N/A

Runoff Analysis

In 1965, the SCS developed the TR-20 model for hydrologic evaluation of flood events for use in analysis of water resource projects. It computes direct runoff resulting from synthetic or natural rainstorms. Flood hydrographs are developed, as well as routing for channels and reservoirs. The TR-20 model was originally intended for large, rural watersheds. The Watershed Modeling computer program incorporates a methodology similar to that used in the TR-20 model to compute and route hydrographs.

Multiple runs of the SCS TR-20 model were used to develop the TR-55 model. The TR-55 model was developed in 1975 and is used for smaller urban areas ranging in area from 1 acre to 2,000 acres. The TR-55 assumes a 24-hour Type I, IA, II and III Rainfall Hyetograph and that 1.4 to 2.1 inches of rain has fallen on the site prior to the design storm. TR-55 determines each individual hydrograph and routes them to an outlet point. (See Appendix A for typical runoff coefficients.) The results of our Watershed Modeling are summarized in Table 3 below.

TABLE 3 SUMMARY OF HYDROLOGIC DATA								
	SE-10	**SE-20**	**SE-30**	**SE-40**	**SE-50**	**SE-60**	**SE-70**	**SE-80**
Area (acres)	46.8	55.1	45.8	69.4	114.8	88.9	48.3	133.7
EXISTING DEVELOPMENT CONDITION								
SCS Curve Number	85	85	85	84	84	84	84	84
Time of Concentration (TC) min.	39.7	80.1	99.9	59.6	146.5	92.2	79.4	79.5
Impervious Fraction (%)	25	6	15	20	16	4	12	10
25-Year Storm Peak Discharge, Q (cfs)	20.5	15.8	12.4	23.9	25.0	22.3	13.0	37.6
FULL DEVELOPMENT CONDITION								
Weighted CN No.	87	87	87	86	86	86	86	86
Time of Concentration TC (min.)	12.9	26.5	18.8	26.1	31.5	15.9	26.0	21.2
Impervious Fraction (%)	30	25	30	25	25	25	25	25
25-Year Storm Peak Discharge, Q (cfs)	31.7	29.6	28.2	36.5	57.2	54.6	25.7	75.7

Flood Routing

Flood routing refers to the process of calculating the passage of a flood hydrograph through a system. Channel Routing (through a piped or open channel system) and Storage Routing (through a reservoir) accounts for the amount of water stored in the stream or reservoir when calculating downstream peak flows.

<u>Channel Routing</u>

For the South End Basin, the Modified Att-Kin (MAK) method was used to determine the effect of channel storage when routing and combining subbasin flows. This method used channel cross-section geometry and longitudinal slope to determine storage and time coefficients. The continuity equation and the manning equation (or field flow tests) are used to calculate a downstream hydrograph in which the peak flow is both lower in quantity and later in time.

For designs in small watersheds, there may be insignificant amounts of flow in defined stream channels. In terms of the hydrologic cycle, the channel processes for such drainage areas are unimportant with respect to design. As the size of the drainage area increases, or when a design is required at a location with a large contributing area upstream of the design location, channel processes must be considered to maintain a reasonable level of design accuracy.

For the South End Basin, MAK channel routing coefficients for all subbasins do not significantly lower the peak flow rates; therefore, the individual peak flow rates can simply be added at their combination nodes. (The individual subbasin and the combined peak flow rates for the 25-year, 24-hour storm are shown on **Exhibit 5**.)

<u>*Storage Routing (Stormwater Detention)*</u>

Stormwater detention is incorporated into the drainage system to reduce the peak rate of discharge by storing excess flow during the most intense portion of the storm, then releasing this flow as conveyance capacity in the drainage system becomes available. Studies have shown that this practice can be effective, if detention is placed on the main drainage channel, or within subbasins in the upper portion of the watershed. The design rate of release from the detention pond may be based on the capacity of a downstream drainage structure; or, in a drainage basin where development or other land use changes are occurring, the rate of release may be limited to the current peak flow rate. (In this case, a detention pond would be sized to store excess runoff anticipated with future development and to release no more than peak flows associated with present development.) This is desirable where land use changes may cause flows that overload portions of an existing downstream conveyance system.

There are essentially two detention methods: "on-site" and "regional." On-site detention is defined as runoff detention installed with each development to reduce the peak runoff to a certain mandated value. The current practice is on-site detention, as described in the City's General Design Standards as follows: "Detention basins will be designed so that release rates downstream of the development do not exceed the 10-year frequency design storm flows for existing land use conditions. These release rates cannot increase the flooding conditions downstream. The detention basins may be either off-line as a separate basin, or on-line and designed as part of a swale system."

It is assumed that this requirement was amended as recommended in Section 6.2 of the 1988 Oregon City Drainage Master Plan as follows: "Each detention facility shall be designed to reduce the 25-year recurrence interval peak flow, based on after development on-site conditions to that peak flow that would have occurred during a 10-year recurrence interval event, based on before development on-site conditions." Although it does provide a measure of protection for the downstream drainage system, a policy of requiring on-site detention results in numerous small detention basins throughout the community. These basins are difficult to monitor when they become numerous and, thus, often lack funding for the maintenance required to keep them functioning properly. In addition, modeling has shown, as described below, that on-site detention ponds, as currently designed, may be full during peak storm events.

Regional detention is defined as a storage facility that receives runoff from a large area and is sized to attenuate the peak in that runoff. "Sub-regional" detention refers to facilities located within a basin, smaller than regional facilities that are sited based on geographic suitability. Regional and sub-regional detention basins offer the advantage of a lower level of monitoring and maintenance effort, due to the decreased total number of basins. Maintenance costs can be spread across a group of benefitting property owners through stormwater utility fees or taxes. When these facilities are owned and operated by the City, maintenance can be done on a scheduled basis, ensuring that the basins will function as planned during design storm events. In addition, regional detention basins can be situated to take advantage of natural landforms, decreasing construction cost. They can also be incorporated into parks or open spaces, or wetlands, thus distributing the cost of property acquisition through multiple use.

The South End basin was investigated to determine the necessity for regional detention. One factor to consider in determining the need for regional detention is the ability of the collection system to handle the 25-year design storm, without significant damage to structures, erosion and/or siltation. During field investigation, the existing drainage system was inspected to determine the most cost-effective method of improving drainage facilities to carry the design flows without damage. As presently constructed, the primary portion of the storm drainage collection system requiring upgrading is located in South End Road, between South End Court and Forest Ridge Lane. With improvements in this location, no upstream sub-regional detention would be required to protect drainage system structures.

Another consideration in determining the need for regional detention is the ability of downstream drainage basins to accommodate increases in flow, due to upstream development. Increased flows may overtax portions of the existing downstream conveyance system, thus requiring system replacement or costly improvements. In addition, the downstream channel has sized itself to the past flow rates. Significant increases may cause erosion of stream banks. Stormwater detention in upstream basins, therefore, can store excess runoff anticipated with future development, and release no more than the peak flows associated with present development. The stream channel downstream of the South End Basin flows into Beaver Creek, which passes through Sevcik Pond and into the Willamette River. The downstream area is primarily agricultural, having Highway 99E as the only road crossing. Although this downstream area is outside the Urban Growth Boundary and is primarily agricultural land use, large increases in stormwater runoff is not recommended.

For purposes of calculating regional detention requirements, the flow attenuation of upstream on-site detention was ignored, assuming a scenario where these impoundments were filled prior to the modeled 25-year storm event. This is based on research and modeling done in King County, Washington (see **Reference 12**). This study demonstrated that current "single event" design methodologies do not simulate actual performance of detention ponds. Field calibration of a continuous simulation model of on-site detention ponds led to the following conclusion:

> *"The generally poor performance is the result of the ponds filling and overtopping at a frequency greater than the design storm. The reason for this is the inherent assumption in any event-based design that the pond is empty when an event begins. Because pre-developed runoff rates in the Puget Sound area are low, relative to post-developed rates, the ponds drain slowly and contain water for many consecutive days during the winter. Thus, when a large event occurs, the full pond volume is not available and the pond overtops. When a detention pond is full, pond inflows are not detained, and the outflow nearly equals the inflow, increasing the potential for downstream flooding and erosion."*

Detention facilities should be constructed with consideration to their aesthetic appeal, utilizing curved shorelines and landscaping. During the design phase of these facilities, the design team should seek to incorporate multiple use features including wetland enhancement, stream channel improvement, stormwater detention, pedestrian/bicycle paths, parks, and open space. Stormwater detention overflow facilities should be designed to pass storms between the 25-year and 100-year design storms directly into the major drainage system channel without overtopping.

Water Quality

On November 16, 1990, the Environmental Protection Agency (EPA) published regulations requiring stormwater discharge permits, as a part of its National Pollution Discharge Elimination System (NPDES). Listed in Section 40, the Code of Federal Regulations (40CFR) parts 122, 123 and 124, these rules implement Sections 401 and 402(p) of the 1972 Clean Water Act, and became effective December 17, 1990. The regulations apply to cities and unincorporated urbanized areas having populations greater than 100,000. Regulated agencies in the local region include Multnomah and Washington Counties, including some cities and agencies within these counties, and the City of Portland. These regulations cover industrial stormwater dischargers under individual or group permits. Cities and counties must prepare detailed management plans that include water quality testing, pollutant source identification, and a plan to reduce pollution using appropriate management practices. Although Clackamas County and Oregon City are not listed as regulated agencies in the 40CFR NPDES stormwater regulations, Clackamas County and nine co-applicants, including Oregon City, have submitted a Permit Application as a group. The final NPDES stormwater permit is expected to be issued shortly after completion of this report. Compliance with NPDES requirements will certainly be a learning process, and the related water quality considerations should form the foundation of a stormwater management plan, including an update of stormwater design standards.

Natural Drainage System Concepts

The traditional stormwater control method for South End Creek would require, at ultimate build out, a continuous network of pipes, beginning at the street catch basins and ending at the outfall, in an open channel at the downstream end of the Basin. Experience developed over the last thirty years has revealed significant problems with past stormwater control practices. Recently, planners and developers have used the concepts of "Natural Drainage" and "Major-Minor Systems." Details of these concepts, summarized below, are provided in **References 1** through **3**.

In a natural drainage system, the drainage course, over time, sizes itself to respond to the varying amounts of runoff. Low-flow channels form, which accommodate storms of about 2-year recurrence intervals, or less, and flood plains form for the major storm events. South End Creek is one such natural channel that has formed over the years. Constructing a drainage system patterned after this natural system offers the following advantages over piped systems:

- Increased potential for infiltration.
- Water quality improvement.
- Aesthetic appeal.
- Potential cost savings.
- Decrease risk of flooding to buildings.

This type of system uses the existing natural drainage system to the fullest extent possible, minimizing the use of underground storm sewers. Where drainage channels need to be constructed, wide, shallow swales lined with grass, or native vegetation, are preferred over deep narrow ditches. Natural channels are generally referred to as streams, creeks or swales, while constructed channels are most often called ditches or, simply, channels. These watercourses can be defined as follows:

- <u>Natural Channels</u> are defined as those which have occurred naturally, due to the flow of surface waters; or those that, although originally constructed by human activity, have taken on the appearance of a natural channel, including a stable route and biological community. They may vary hydraulically along each channel reach and should be left in their natural condition, wherever feasible or required, in order to maintain natural hydrologic functions and wildlife habitat benefits from established vegetation.

- Constructed Channels are those constructed or maintained by human activity and include bank stabilization of natural channels. Constructed channels shall be either rock-lined, vegetation-lined, or lined with appropriately "bio-engineered" vegetation.

- Vegetation-lined Channels are the preferred type of constructed channels when properly designed and constructed. The vegetation stabilizes the slopes of the channel controls erosion of the channel surface, and removes pollutants. The channel storage, low velocities, water quality benefits, and greenbelt multiple-use benefits create significant advantages over other constructed channels. The presence of vegetation in channels creates turbulence, which results in loss of energy and increased flow retardance. Therefore, the design engineer must consider sediment deposition and scour, as well as flow capacity.

- Rock-line Channels are necessary where a vegetative lining will not provide adequate protection from erosive velocities. They may be constructed with quarry spall riprap, gabions, or slope mattress linings. The rock lining increases the turbulence, resulting in a loss of energy and increased flow retardance. Rock lining also permits a higher design velocity and, therefore, a steeper design slope than in grass-lined channels. Rock linings are also used for erosion control at culvert/storm drain outlets, at sharp channel bends, channel confluences, and locally steepened channel sections. Rock-lined channels should only be used when careful consideration has been shown that vegetated channels are not feasible.

The Major-Minor concept was developed to eliminate flooding, while minimizing the cost of the storm drainage system. The minor system, consisting of underground pipes and culverts and/or swales, is designed to transport more frequent storms, while minimizing inconvenience to the public. Major systems consist primarily of surface grading, shallow swales and natural channels. This system is designed to accept some inconvenience, but to eliminate significant flood damage during large storms.

Typical guidelines for this design concept are as follows:
- Site grading and building location should be done so that in a complete failure of the minor storm system no buildings will be flooded by the design storm flow.
- Where channels cross a roadway, the low point should be located directly over the culvert.
- Use the 25-year storm to design the minor drainage system.
- Perform more detailed analysis of problem areas (such as sump areas, relatively flat areas and structures located lower than streets or parking lots).
- Use the 100-year storm to design the major drainage system.

This is the conceptual framework currently being implemented in the areas designated "Rural Residential" (RUR) for this study, and are proposed to be implemented for the proposed improvements to South End Creek and adjoining storm drainage improvements where the channel crosses South End Road.

In addition, the following considerations should be given when designing natural drainage systems:
- Wetland mitigation areas, water quality ponds, and the construction or reconstruction of open channels should be designed and landscaped with the goal of stream maximizing stream health, utilizing sedimentation and biological uptake as mechanisms of pollutant removal.
- Existing wetland areas, whether designated as jurisdictional wetlands or not, should be improved or rehabilitated to maximize their usefulness for water quality enhancement.

Infiltration

The use of dry wells for roof drainage was considered as a measure to reduce surface runoff by recharging stormwater into the ground. Other potential advantages of this type of on-site infiltration include decreasing the cost of a conventional drainage system, improving water quality, and increasing dry-weather stream flows. Disadvantages of these systems include practical difficulties in keeping sediment out of the structure during construction, the need for careful construction of the structures, and the risk of groundwater contamination.

Soil permeability and depth to bedrock are the primary limitations to the widespread use of infiltration structures. Soil permeability requirements vary, but 0.6 in/hr is normally required at a minimum. This permeability should be measured on site by percolation tests typically used to design septic tank systems. The "perc" test should be run on the soil horizon with the minimum permeability. The minimum depth to bedrock should be 5 feet. Infiltration structures should be designed to allow bypassing of runoff during extreme storms or when the facility clogs. Infiltration systems are typically designed for the control of storms less than a 10-year design frequency.

Since the soils in this drainage basin are in general not suited for infiltration, widespread use of dry wells for on-site disposal of stormwater is not recommended. However, individual sites may be have specific topography and soils suited to this method. In this case, systems should be designed to the specifications listed above.

PROPOSED IMPROVEMENTS (Revised May 1997)

In addition to the aforementioned analysis and research, several additional factors were considered in the analysis of options and priorities for drainage improvements in the South End Basin. Property owners along stream channels were notified of the South End Basin plan; field investigation was done to ensure that improvements would minimize impact to the existing development and landscape; areas of local flooding were analyzed; and long-term maintenance was considered. The analysis resulted in four categories or phases of improvement. Phase 1 is considered the highest priority. The remaining phases will be implemented as development occurs in the Basin.

The design, construction, and maintenance of storm drainage improvements in the South End Basin shall comply with applicable design standards as they may be promulgated by the City. The feasibility of a variety of detention and drainage options (e.g., staged detention, longer duration design storms) is to be considered when designing South End Basin storm drainage improvements. Coordination of improvements throughout the basin is desirable. Individual projects in the basin will be required to install site specific storm drainage facilities to convey and control stormwater flow and address surface water quality, subject to City Engineer approval.

Proposed Phased Improvements

Phase 1

The proposed storm pipelines, catch basins, field inlets, and manholes are shown in **Exhibit 6**. Although improvements were developed to retain open channels where practical, at the South End Creek crossing of South End Road, a pipes system is recommended for the following reasons:

- Piped improvements have recently been constructed on the west side of South End Road, near McLoughlin Elementary School.
- The existing open channel ditch along the west side of South End Road, between South End Court and Forest Ridge Lane, has areas of recent erosion. In addition, since the steep side slopes are difficult to maintain, this section has become obstructed with vegetation.
- This area has significant pedestrian traffic from the elementary school, and pedestrian access is inadequate along this ditched section of roadway.

Phase 2

The ultimate flow rate for the entire basin will be attenuated by a combination of on-site, regional, and sub-regional detention facilities. On-site ponds are intended to accommodate flows from 25-year and smaller storm events. Regional and sub-regional facilities are intended to accommodate flows from the 25-year to 100-year storm events.

Locations of regional detention facilities will be sized to maximize available detention without significant alteration of the existing topography. These facilities are proposed to be multi-use dry ponds or wet ponds that utilize and/or enhance existing wetland areas and natural drainage patterns. These areas are ideally suited for multiple uses (e.g., enhanced wetlands, water quality improvement, utility corridor, athletic courts and fields, pedestrian/bicycle path, park, open space, and street connection). Where appropriate, secondary uses will be integrated into these areas. Roadway embankments will be considered for flow control structures (e.g., Parrish Road connection between South End Road and Central Point Road).

Regional and sub-regional facilities will be located according to the following alternatives:

Alternative 1: Two detention areas are illustrated on **Exhibit 7** that are comprised of three ponds providing approximately 30 acre-feet of storage capacity by increasing the size of existing ponds. Detention Area No. 1 can be constructed between the elevations of 404 and 412. Detention Area No. 2 can be constructed between the elevations of 392 and 402, with a top surface area at full storage of approximately 3.5 acres. Evaluation of the existing outlet structure and State-registered (ID No. OR02860) dam will be required prior to increasing the storage capacity of this pond.

Alternative 2: A Regional Detention Corridor is illustrated on **Exhibit 8** that is comprised of one or multiple ponds providing approximately 30 acre-feet or more of storage capacity. This corridor provides additional potential regional detention areas to the detention areas identified in Alternative 1. The final location(s) and sizes of detention facilities are to be determined after future study demonstrates feasibility based on a correlation of design issues, including but not limited to: site development, storm water management needs, available land, the potential for a multiple use facility, and funding. Sub-regional detention can be considered at strategic locations to complement or reduce regional design capacity.

Phase 3

This improvement addresses a local flooding problem in Oaktree Subdivision, near the low area in Oaktree Avenue. The combination of relatively flat ground slopes and shallow storm drains creates localized low spots of shallow standing water during storm events. It is proposed to install an additional area drain in the easement area across the 18800 Oaktree Avenue parcel, providing positive drainage away from this low point. Upstream of this lot, it is proposed to install a secondary overflow to the storm drainage detention pond, which was constructed as part of the Cook Street Addition Subdivision. This proposed overflow line flows northerly in Cook Street and discharges into the existing storm drain piping located approximately 700 feet to the north. This area will then drain out of the South End Basin.

Phase 4

Existing drainage channels, located primarily across undeveloped parcels, are proposed to be retained as open channel drainage swales. As these parcels develop, a drainage easement will dedicated along the existing stream channels, constructed as shown in **Exhibit 9** or as approved by the City Engineer. These easements are to be integrated into development site design with the intent of: 1) maintaining the historic drainage route of existing streams and swales in the Basin; and 2) providing water quality enhancement. Private property owners will maintain the easements (through neighborhood groups or individual responsibility). However, if the channels become neglected and surface water is not adequately conveyed, the City will have the ability to perform maintenance operations. The easements will range in dimension from 15 to 30 feet, depending on their configuration and intended use (e.g., a narrower easement may be appropriate for low design flows or if nearby vehicular access is available).

Where existing drainage channels are located on parcels that are not being developed, the existing property owners will be requested to protect the drainage channels from filling or reconfiguration. This request is intended to preserve historic drainage routes and maintain water quality enhancement. If these channels are found to inadequately convey surface water, property owners will be requested to improve the channels to protect against uncontrolled flooding and erosion and enhance water quality. If channel conditions are found to compromise public safety, the City will consider acquiring easements along these channels. The easement would provide the City with the ability to improve and maintain the drainage channels.

Table 4 lists typical channel configurations to accommodate flows from 22 cfs through 274 cfs (based on **Exhibit 9**), varying channel depth from two to four feet and varying longitudinal slope from 0.5% to 2.5%.

TABLE 4 TRAPEZOIDAL CHANNEL ANALYSIS AND DESIGN							
Bottom Width (ft)	z-Left (H:V)	z-Right (H:V)	Manning "n"	Channel Slope (ft/ft)	Channel Depth (ft)	Channel discharg e (cfs)	Mean Velocity (fps)
2.00	4.00	4.00	0.100	0.005	2.00	22.14	1.11
2.00	4.00	4.00	0.100	0.010	2.00	31.31	1.57
2.00	4.00	4.00	0.100	0.015	2.00	38.35	1.92
2.00	4.00	4.00	0.100	0.020	2.00	44.28	2.21
2.00	4.00	4.00	0.100	0.025	2.00	49.51	2.48
2.00	4.00	4.00	0.100	0.005	2.50	38.06	1.27
2.00	4.00	4.00	0.100	0.010	2.50	53.82	1.79
2.00	4.00	4.00	0.100	0.015	2.50	65.92	2.20
2.00	4.00	4.00	0.100	0.020	2.50	76.11	2.54
2.00	4.00	4.00	0.100	0.025	2.50	85.10	2.84
2.00	4.00	4.00	0.100	0.005	3.00	59.63	1.42
2.00	4.00	4.00	0.100	0.010	3.00	84.34	2.01
2.00	4.00	4.00	0.100	0.015	3.00	103.29	2.46
2.00	4.00	4.00	0.100	0.020	3.00	119.27	2.84
2.00	4.00	4.00	0.100	0.025	3.00	133.35	3.17
2.00	4.00	4.00	0.100	0.005	3.50	87.54	1.56
2.00	4.00	4.00	0.100	0.010	3.50	123.80	2.21
2.00	4.00	4.00	0.100	0.015	3.50	151.62	2.71
2.00	4.00	4.00	0.100	0.020	3.50	175.08	3.13
2.00	4.00	4.00	0.100	0.025	3.50	195.74	3.50
2.00	4.00	4.00	0.100	0.005	4.00	122.41	1.70
2.00	4.00	4.00	0.100	0.010	4.00	173.11	2.40
2.00	4.00	4.00	0.100	0.015	4.00	212.01	2.94
2.00	4.00	4.00	0.100	0.020	4.00	244.81	3.40
2.00	4.00	4.00	0.100	0.025	4.00	273.71	3.80

PRELIMINARY CONSTRUCTION COST ESTIMATES

PROPOSED STORM DRAINAGE IMPROVEMENTS		
PHASE	**DESCRIPTION**	**COST** *(1995 dollars)*
1	12-inch and 48-inch Storm Drain, Manholes and Catch Basins in South End Road, South End Court to Forest Ridge Lane.	$166,500
2	Regional Detention Ponds/ Wetland Enhancement	$504,000
3	Oaktree Subdivision Drainage Improvements.	$101,000
4	30-foot Wide Drainage Channel Improvements and Greenway Acquisition.	$155,000
	TOTAL	**$926,500**

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12. Barker, B., R. Nelson, and M. Wigmosta, "Performance of Detention Ponds Designed According to Current Standards", Stormwater Management Manual for the Puget Sound Basin, 1992.

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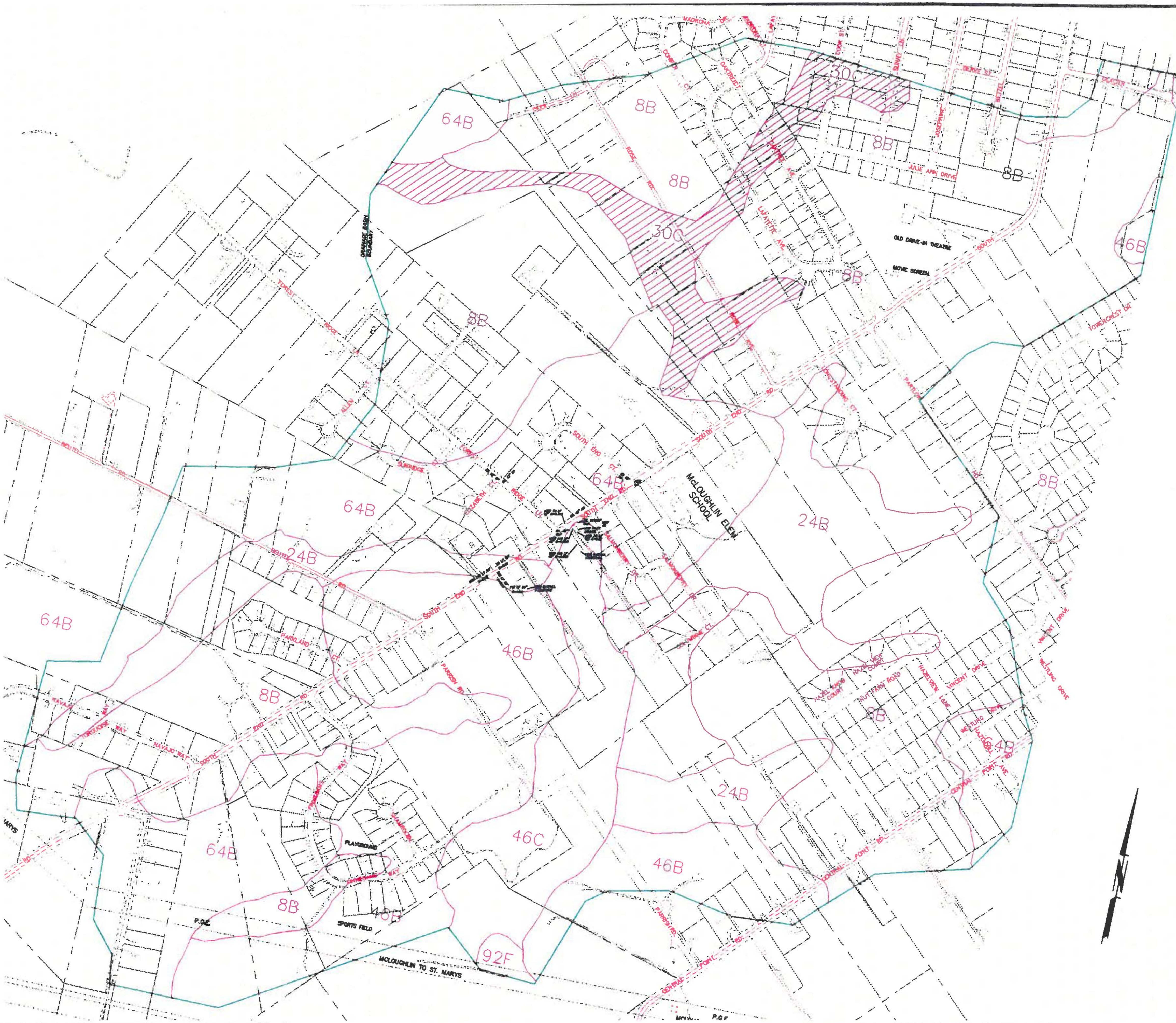
STORM DRAINAGE PLAN
SOUTH END BASIN



☐	*HYDROLOGIC GROUP C*
▨	*HYDROLOGIC GROUP D*

LEGEND

Type	Description	Group
8B	Bornstedt silt loam, 0-8% slopes	C
24B	Cotrell silty clay loam, 2-8% slopes	C
30C	Delena silt loam, 3-12%, slopes	D
46B	Jory stony silt loam, 3-8% slopes	C
46C	Jory stony silt loam 8-15% slopes	C
64B	Nekia silty clay loam 2-8% slopes	C

SOIL BOUNDARY DESIGNATION
DRAINAGE BASIN BOUNDARY

EXHIBIT 1
SOIL MAP

PREPARED FOR:
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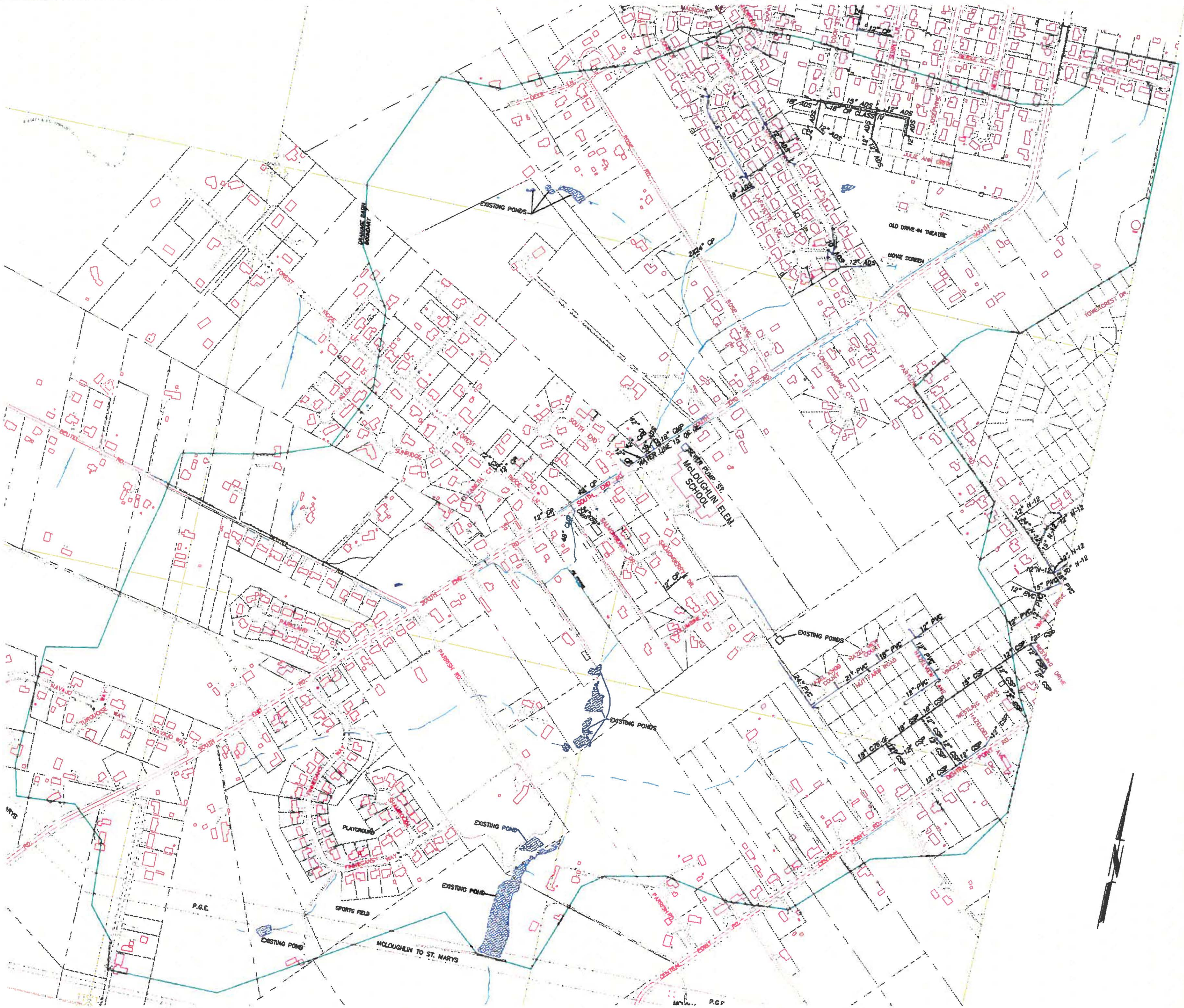
320 WARNER MILNE ROAD
OREGON CITY, OREGON 97045-4000
3/29/96

PLANNING CIVIL ENGINEERING LAND SURVEYING
KAMPE ASSOCIATES INC

Scale: 1"=600'

STORM DRAINAGE PLAN
SOUTH END BASIN



LEGEND

EXISTING STREAM/DITCH
EXISTING STORM LINE
PROPERTY LINE
DRAINAGE BASIN BOUNDARY
EXISTING BUILDING

EXHIBIT 2

EXISTING DRAINAGE FACILITIES

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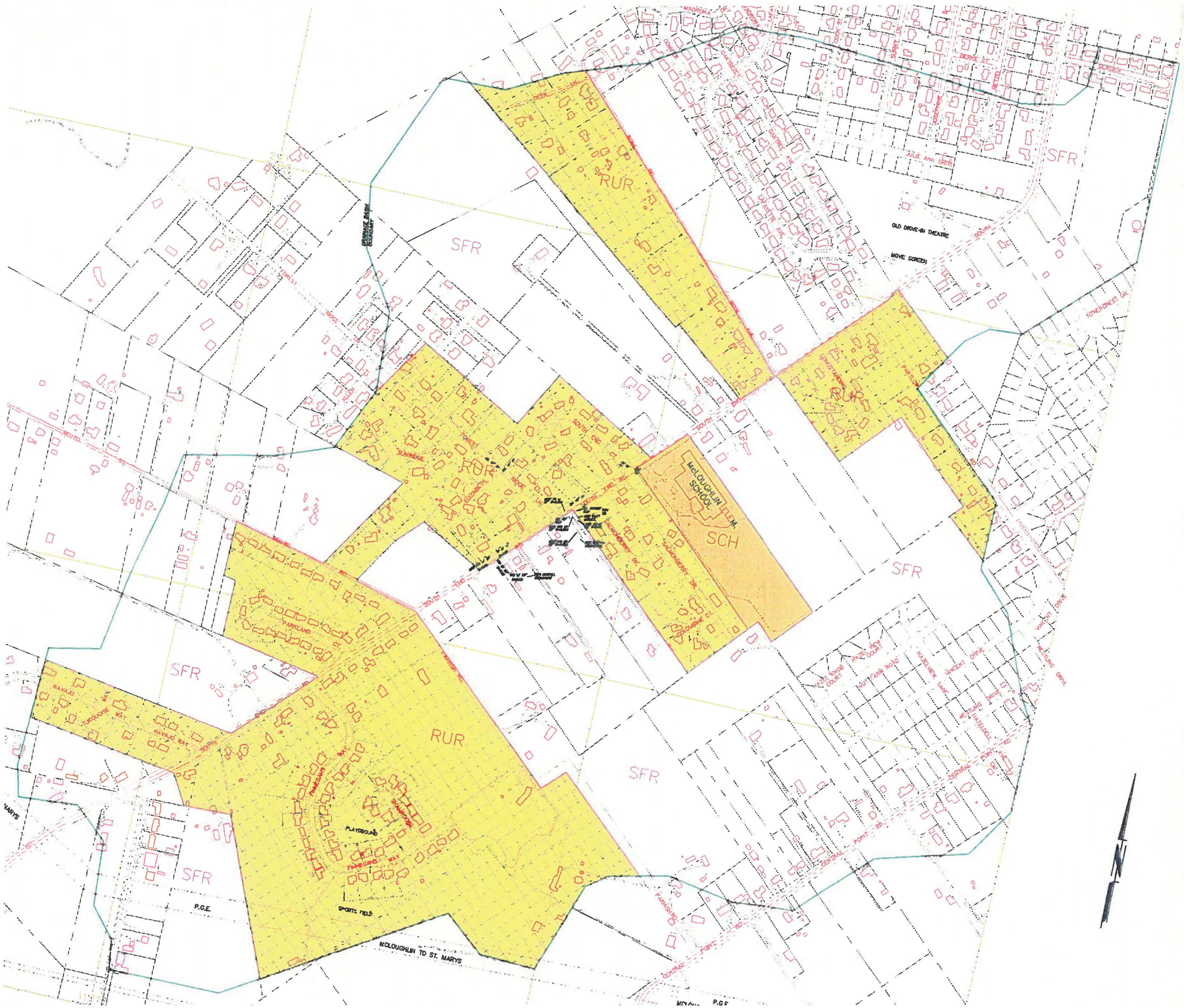
Scale: 1"=600'

STORM DRAINAGE PLAN
SOUTH END BASIN



LEGEND

PROPERTY LINE

EXISTING STRUCTURE

EXISTING EDGE OF PAVING

QUARTER SECTION LINE

DRAINAGE BASIN BOUNDARY

RURAL AREAS

SCHOOL

SINGLE FAMILY RESIDENTIAL

EXHIBIT 3

LAND USE MAP

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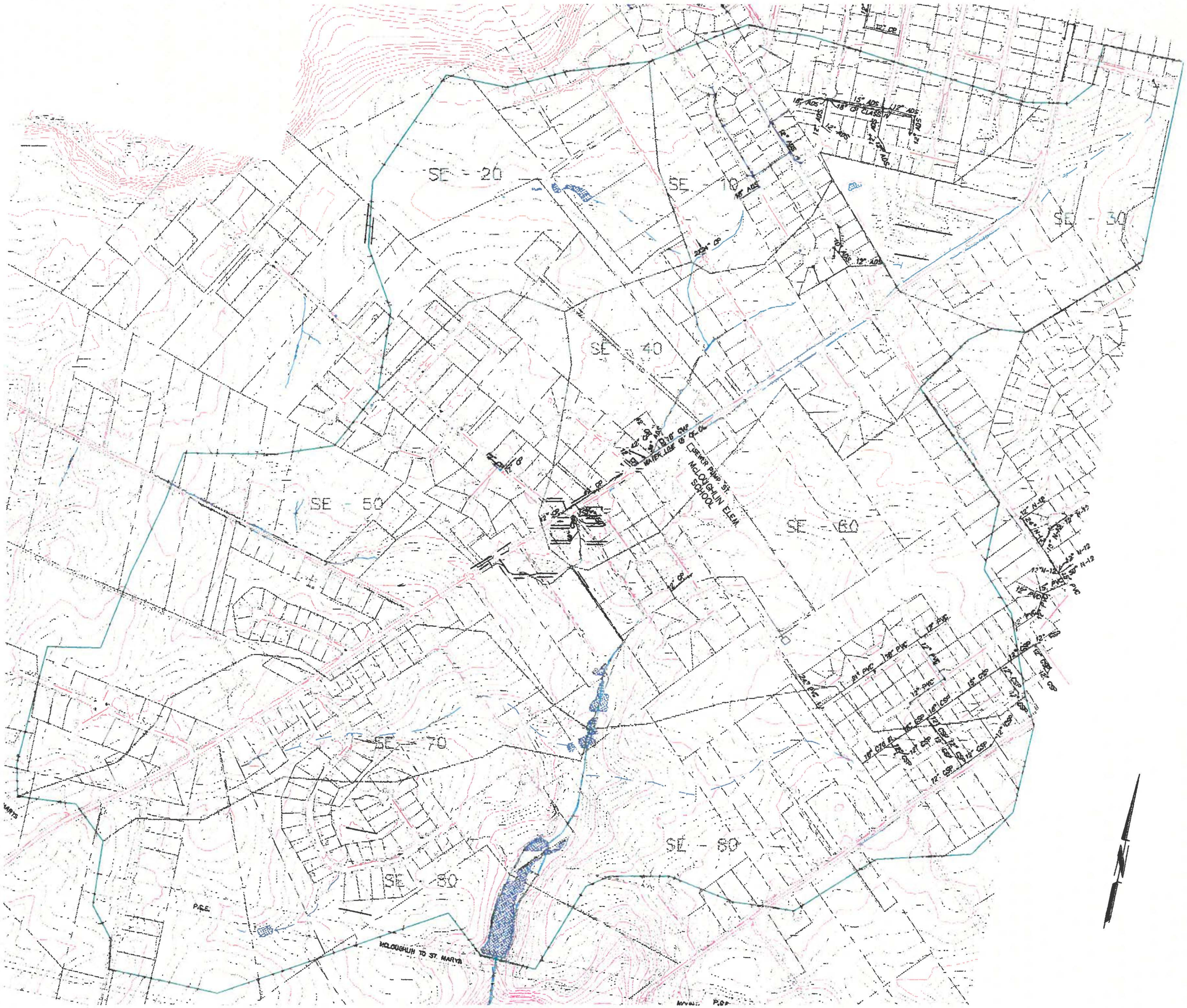
Scale: 1"=600'

STORM DRAINAGE PLAN
SOUTH END BASIN



LEGEND

P-10	SUBBASIN NUMBER
	EXISTING STREAM/DITCH
	EXISTING STORM LINE
	PROPERTY LINE
	DRAINAGE BASIN BOUNDARY
	WETLAND STREAMS
	WETLAND POND AREAS
	EXISTING POND

EXHIBIT 4
DRAINAGE SUB-BASINS & WETLANDS

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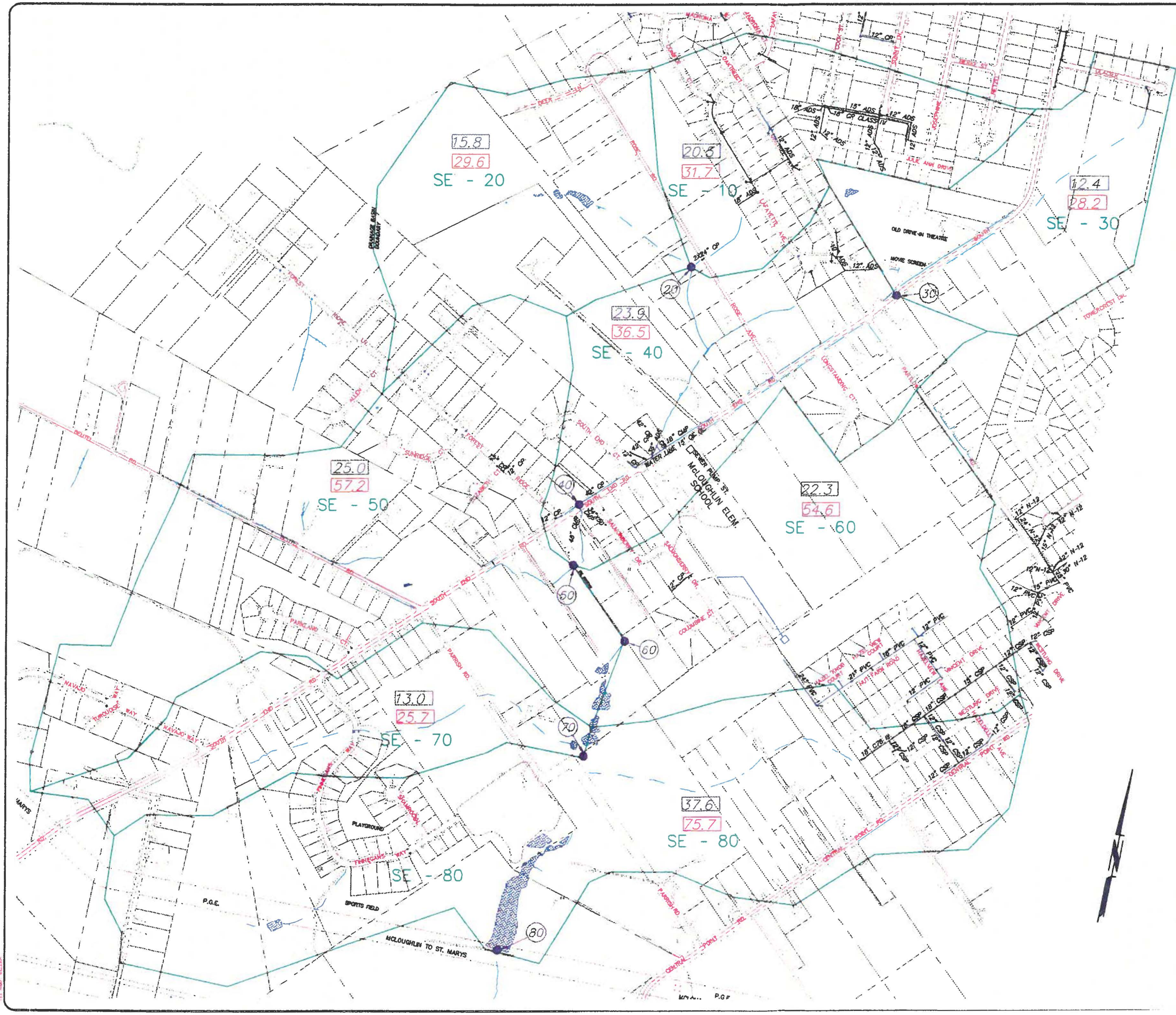
KAMPE ASSOCIATES

Scale: 1"=600'

STORM DRAINAGE PLAN
SOUTH END BASIN



EXISTING AND ULTIMATE FLOWRATES (CFS)- 25

10.6 EXISTING SUBBASIN PEAK FLOWRATE.

10.9 FUTURE SUBBASIN PEAK FLOWRATE,

20 NODE NUMBER

SE-20 SUBBASIN NUMBER

FUTURE COMBINED PEAK FLOW RATE	NODE	SUB-BASINS
61.3	20	SE-10, SE-20
28.2	30	SE-30
124.1	40	SE-10 THROUGH SE-
181.3	50	SE-10 THROUGH SE-
234.9	60	SE-10 THROUGH SE-
	70	SE-10 THROUGH SE-
	80	SE-10 THROUGH SE-

EXHIBIT 5

SUB-BASIN ANALYSIS
25 YEAR FLOWS

PREPARED FOR:
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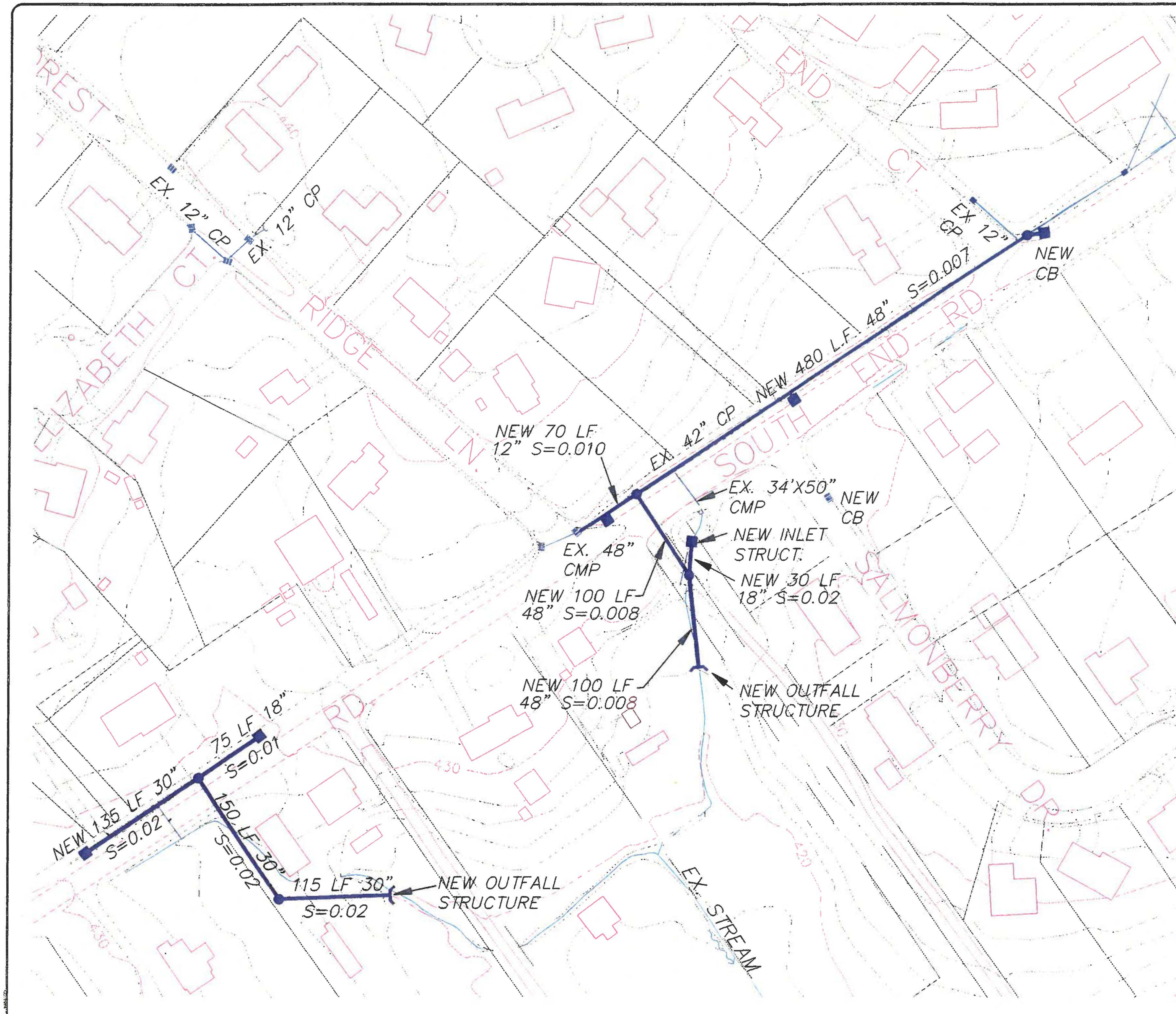
Scale: 1"=600'

STORM DRAINAGE PLAN
SOUTH END BASIN



LEGEND

- EXISTING BUILDING
- EXISTING STREAM/DITCH
- EXISTING CATCH BASIN
- PROPOSED CATCH BASIN
- PROPOSED STORM MANHOLE
- PROPOSED DRAINAGE STRUCTURE

EXHIBIT 6
PROPOSED SOUTH END ROAD IMPROVEMENTS

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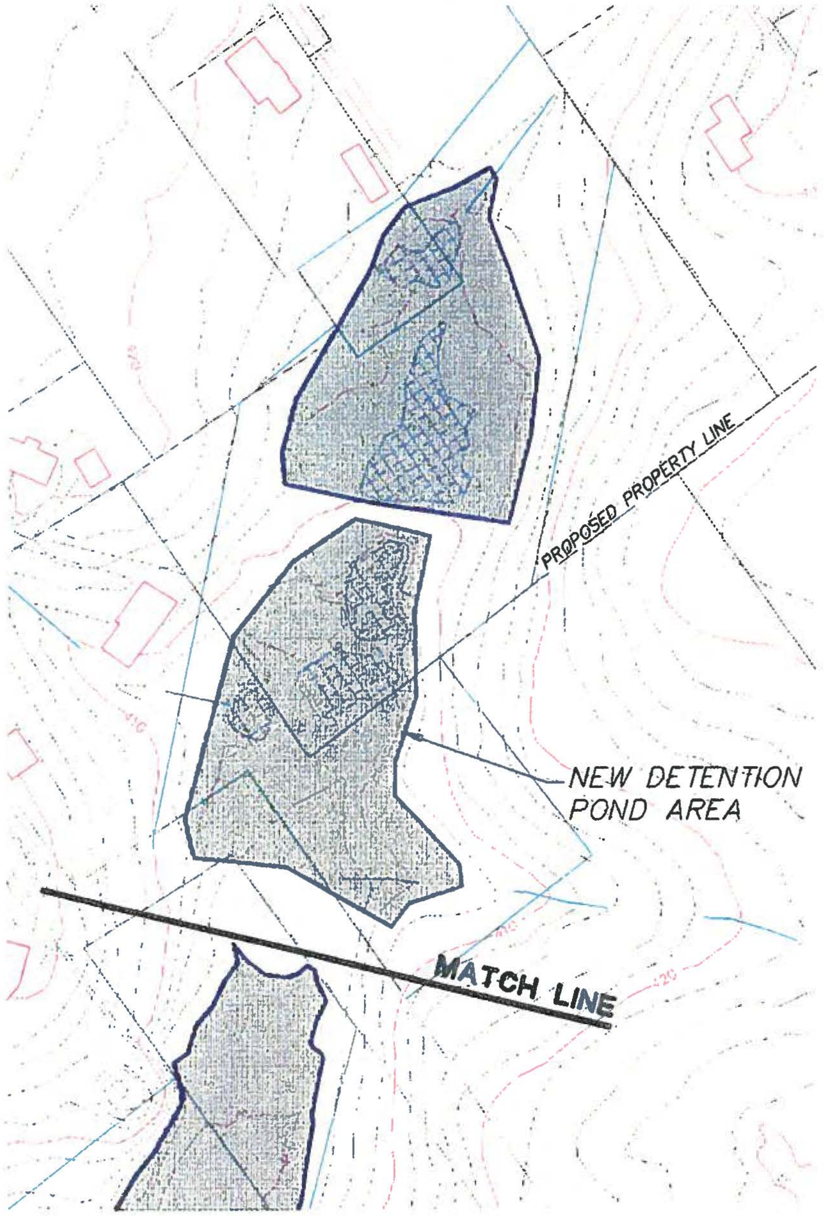
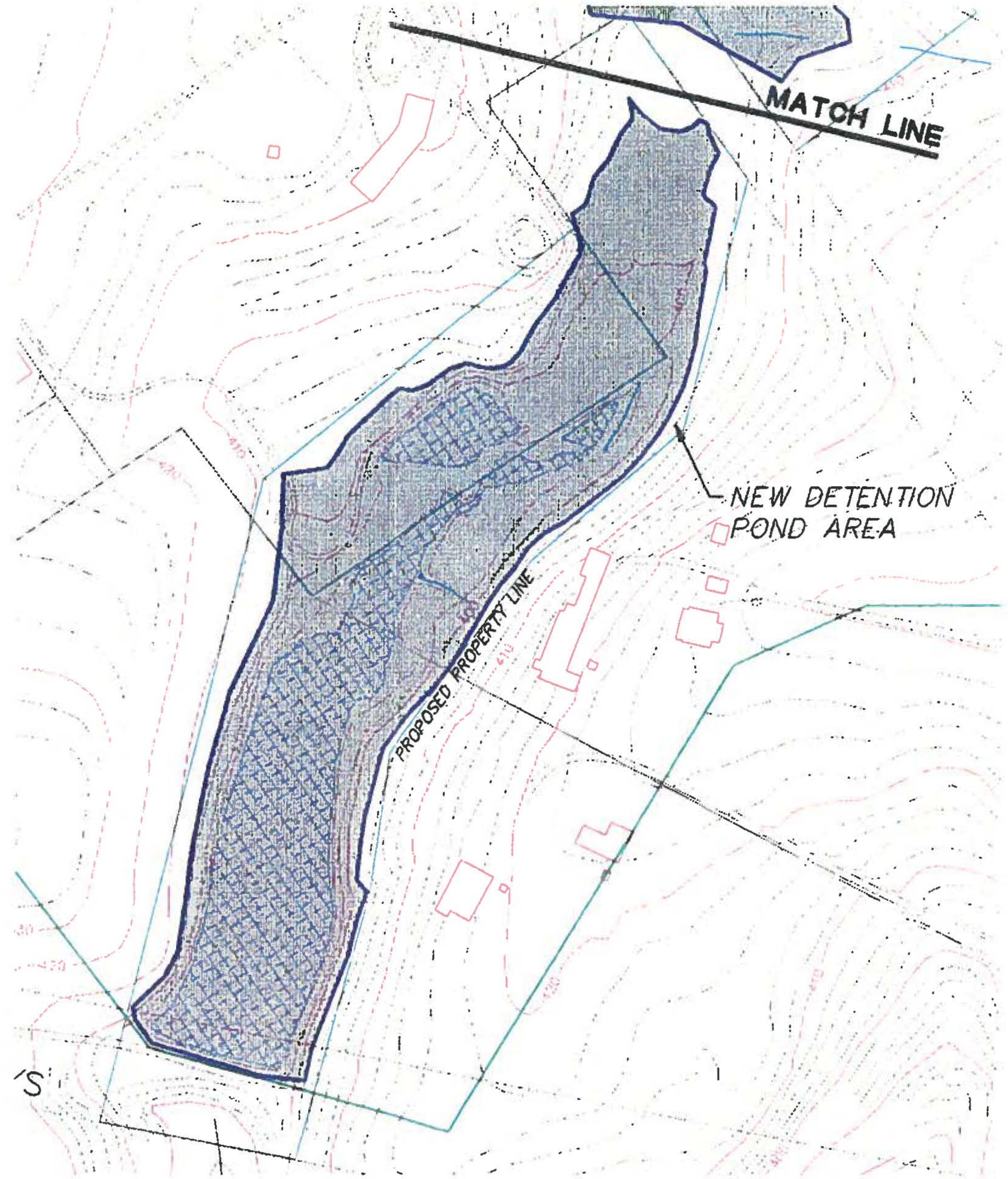
Scale: 1"=100'

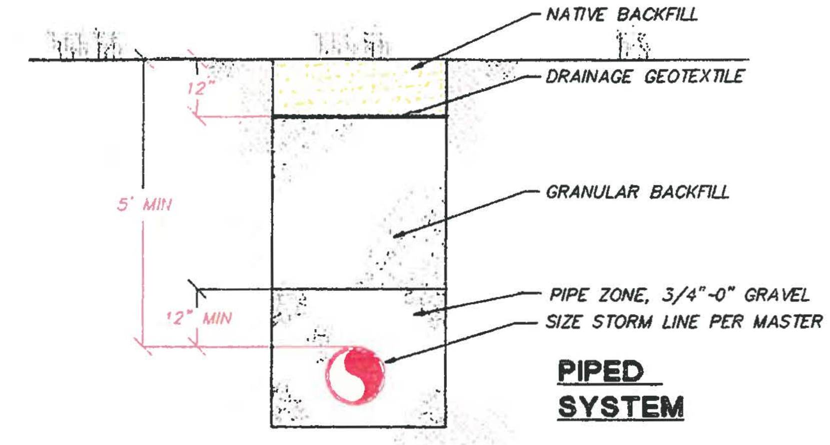
STORM DRAINAGE PLAN
SOUTH END BASIN



DETENTION AREA NO.1



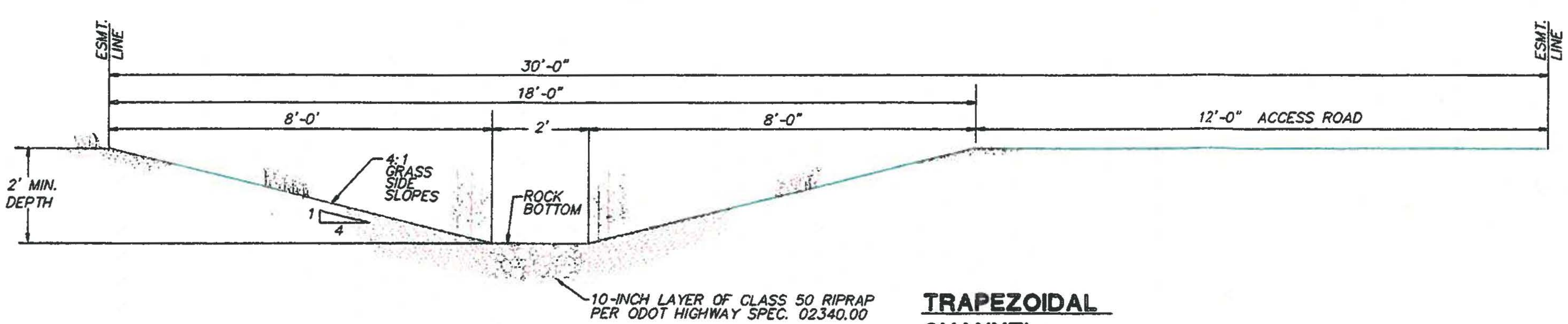
DETENTION AREA NO.2



PIPED SYSTEM

LEGEND

- EXISTING BUILDING
- DRAINAGE BASIN BOUNDA
- NEW DETENTION POND
- EXISTING POND



TRAPEZOIDAL CHANNEL

EXHIBIT 7

PROPOSED DETENTION FACILITIES
ALTERNATIVE 1

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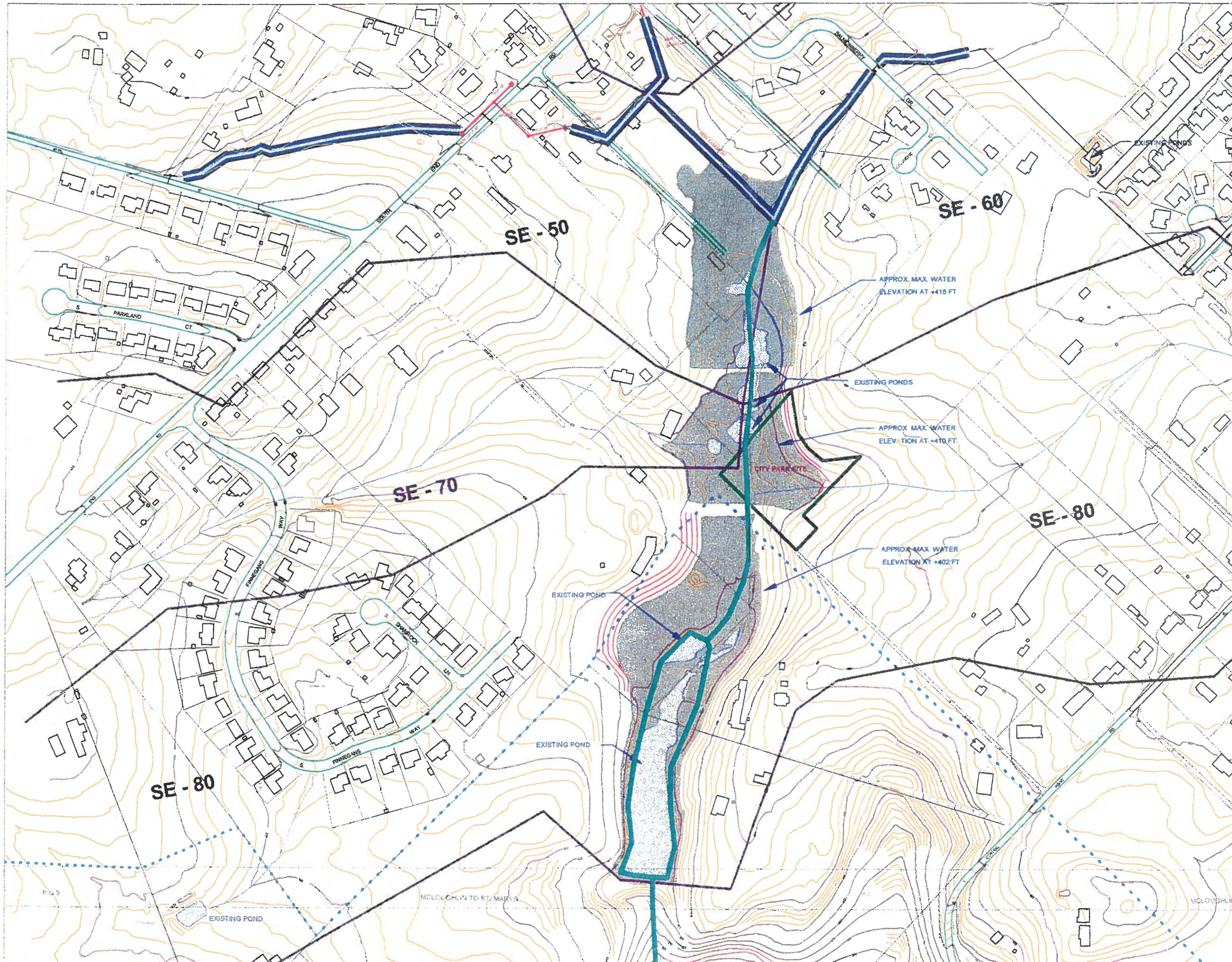
Scale: 1"=200'



STORM DRAINAGE PLA
SOUTH END BASIN

LEGEND

SE-70	Sub-Basin Number
	Drainage Basin Boundary
	Water Resource Overlay Area
	15 Foot Easement
	30 Foot Easement
	New Storm Line
	Existing Storm Line
	City Park Site Boundary
	10 Foot Countours
	2 Foot Countours
	Urban Growth Boundary
	Existing Ponds
	Potential future 100-year storm detention area

N W E S

0 100 200 300 400 500 600 Fe

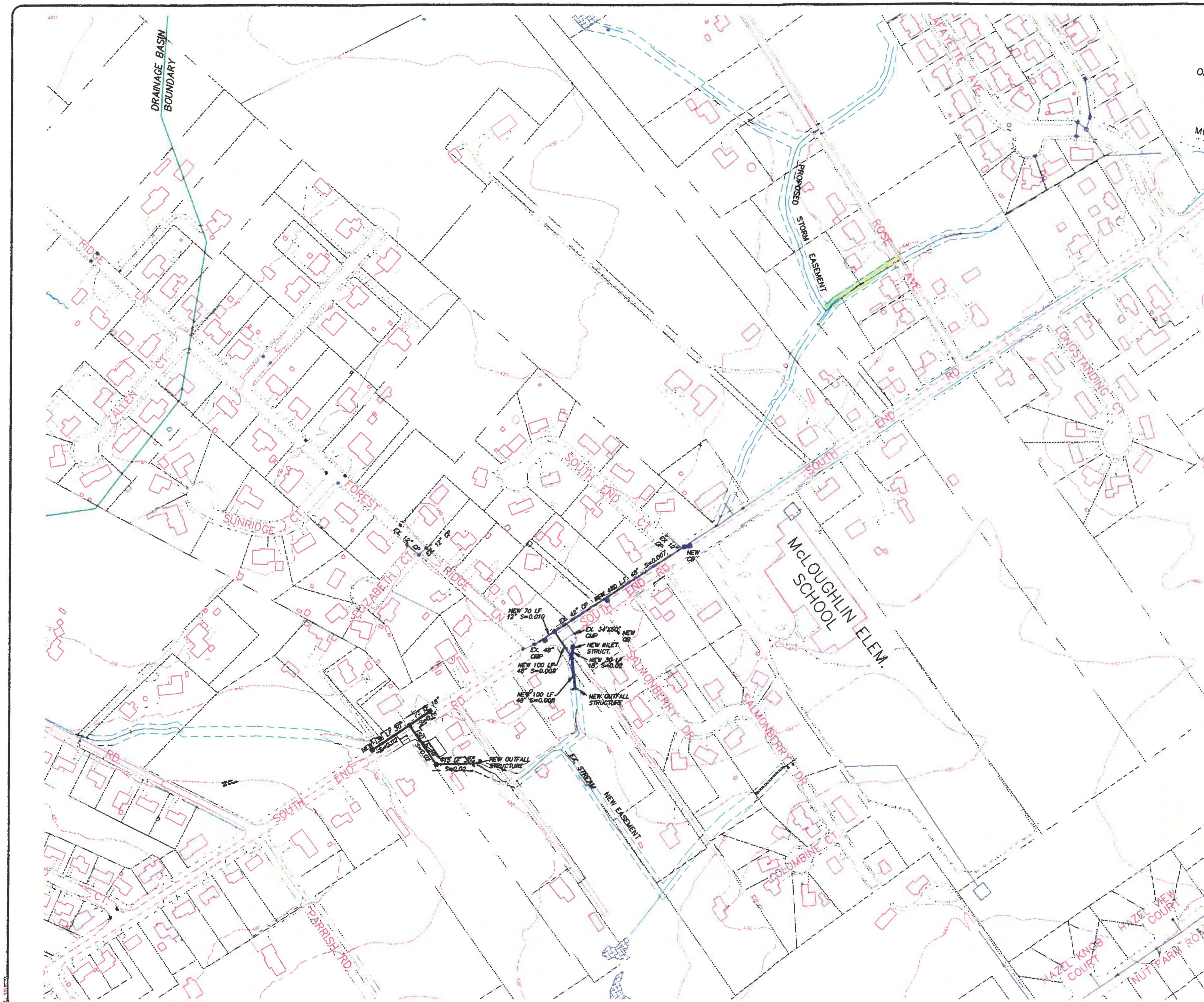
Exhibit 8
Alternative 2
Regional Detention Corrior

Data prepared by Kampe Associates Inc. for the City of Oregon City, 3/29/96.
Map prepared by the City of Oregon City GIS Services, 2/3/98.

The information on this map is derived from Oregon City's digital database. However, there may be map errors or omissions. Please contact Oregon City directly to verify map information. Notification of any errors will be appreciated.

Plot date: Feb 3, 1998; g:\av_proj\mark\pr9602\se_b

STORM DRAINAGE PLAN
SOUTH END BASIN



LEGEND

PROPOSED 30' STORM EASEMENT

DRAINAGE BASIN BOUNDA

EXISTING BUILDING

EXISTING POND

EXHIBIT 9

PROPOSED EASEMENTS

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320 WARNER MILNE ROAD
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Scale: 1"=300'

APPENDIX A

REFERENCE TABLES

The following **Reference Tables** are from The ***Eagle Point*** *"Watershed Modeling"* documentation. Runoff Coefficients, Manning's Flow Coefficients, Runoff Curve Numbers, and Structure Coefficients from these tables were used in modeling for this basin. Watershed modeling methods and parameters used in this study are summarized in **Appendix C.**

Appendix A: Reference Tables

The following tables are included for your convenience

- Runoff Coefficients
- Manning's Roughness Coefficients for Sheet Flows
- Manning's Roughness Coefficients for Channel Flows
- Constants for Inlet Control Design Equations
- Manning's n Values for Selected Conduits
- Entrance Loss Coefficients (k_e)
- Runoff Curve Numbers
- K Coefficient for Estimating Travel Time for Shallow Flow in TR-55 Method

Runoff Coefficients

Description of Area		Coefficient
Business	Central Business	0.70 - 0.95
	District and Local	0.50 - 0.70
Residential	Single Family	0.35 - 0.45
	Multi-units	0.40 - 0.75
	1/2 acre lots or larger	0.25 - 0.40
Industrial:	Light	0.50 - 0.80
	Heavy	0.60 - 0.90
	Parks, cemeteries	0.10 - 0.25
	Playgrounds	0.20 - 0.35
	Railroad yards	0.20 - 0.40
	Unimproved	0.10 - 0.30

For Impervious Surfaces

Description of Surface	Coefficient
Asphalt	0.70 - 0.95
Concrete	0.80 - 0.95
Roofs	0.75 -0.95

For Pervious Surfaces

Slope	SCS Soils			
	A	B	C	D
Flat (0-2%)	0.04	0.07	0.11	0.15
Average (2 - 6%)	0.09	0.12	0.16	0.20
Steep (Over 6%)	0.13	0.18	0.23	0.28

Manning's Roughness Coefficients for Sheet Flow

Surface	Manning's n Value
Smooth concrete	0.012
Ordinary concrete lining	0.013
Good wood	0.014
Vitrified clay	0.015
Brick with cement mortar	0.014
Cast iron	0.015
Corrugated metal pipes	0.023
Cement rubble surface	0.024
Short grass	0.015
Dense grass	0.024
Bermuda grass	0.041
Light underbrush woods	0.40
Dense underbrush woods	0.80
Rangeland	0.13

SOURCE: *Hydraulic Analysis and Design*, Richard H. McCuen, 1989.

Manning's Roughness Coefficients for Channel Flow

Description of Area			Manning's n Range
Unlined Open Channels			
Earth, Uniform Section	Clean, recently completed		0.016 - 0.018
	Clean, after weathering		0.018 - 0.020
	With short grass, few weeds		0.022 - 0.027
	In gravely soil, uniform section, clean		0.022 - 0.025
Earth, fairly uniform section	No vegetation		0.022 - 0.025
	Grass, some weeds		.025 - 0.030
	Dense weeds or aquatic plants in deep channels		0.030 - 0.035
	Sides, clean, gravel bottom		0.025 - 0.030
	Sides, clean, cobble bottom		0.030 - 0.040
Dragline excavated or dredged	No vegetation		0.028 - 0.033
	Light brush on banks		0.035 - 0.050
Rock	Based on design section		0.035 - 0.050
	Based on actual mean section:	Smooth and uniform	0.035 - 0.040
		Jagged and irregular	0.040 - 0.045
Channels not maintained, weeds and brush uncut:	Dense weeds, high as flow depth		0.080 - 0.120
	Clean bottom, brush on sides		0.050 - 0.080
	Clean bottom, brush on sides, highest stage of flow		0.070 - 0.110
	Dense brush, high stage		0.100 - 0.140

Manning's Coefficient for Channel Flow, continued

Description of Area			Manning's n Range
Roadside channels and swales with maintained vegetation (Values shown are for velocities of 2 and 6 ft/sec)			
Depth of flow up to 0.7 ft	Bermuda grass, Kentucky bluegrass, buffalo grass	Mowed to 2 in.	0.045 - 0.070
		Length 4 to 6 in.	0.050 - 0.090
	Good stand, any grass	Length about 12 in.	0.090 - 0.180
		Length about 24 in.	0.150 - 0.300
	Fair stand, any grass	Length about 12 in.	0.080 - 0.140
		Length about 24 in.	0.130 - 0.250
Depth of flow 0.7 - 1.5 ft	Bermuda grass, Kentucky bluegrass, buffalo grass	Mowed to 2 in.	0.035 - 0.050
		Length 4 to 6 in.	0.040 - 0.060
	Good stand, any grass	Length about 12 in.	0.070 - 0.120
		Length about 24 in.	0.100 - 0.200
	Fair stand, any grass	Length about 12 in.	0.060 - 0.100
		Length about 24 in.	0.090 - 0.170

Manning's Coefficient for Channel Flow, continued

Description of Area			Manning's n Range
Natural Stream Channels			
Minor Streams (surface width at flood stage less than 100 ft.)	Fairly regular section	Some grass and weeds, little or no brush	0.030 - 0.035
		Dense growth of weeds, depth of flow materially greater than weed height	0.035 - 0.050
		Some weeds, light brush on banks	0.040 - 0.050
		Some weeds, heavy brush on banks	0.050 - 0.070
		Some weeds, dense willows on banks	0.060 - 0.080
	For trees within channel, with branches submerged at high stage, increase all above values by:		0.010 - 0.020
	Irregular sections, with pools, slight meander, increase value for fairly regular sections by about:		0.010 - 0.020
	Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage	Bottom of gravel, cobbles and few boulders	0.040 - 0.050
		Bottom of cobbles, with large boulders	0.05 - 0.07

SOURCE: *Hydraulic Analysis and Design*, Richard H. McCuen, 1989

K Coefficient for Shallow Flow

Land Use	K
Forest with heavy ground litter, hay meadow	0.25
Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland	0.50
Short grass pasture (outland flow)	0.70
Cultivated straight row (outland flow)	0.90
Nearly bare and untilled (overland flow)	1.00
Grassed waterway	1.50
Unpaved Area	1.60
Paved area (sheet flow); small upland gullies	2.00

SOURCE: *Hydraulic Analysis and Design*, Richard H. McCuen,1989

Constants for Inlet Control Design Equations

Chart Number	Shape and Material	Nomograph Scale	Inlet Edge Description	Equation Form
1	Circular	1	Square edge w/headwall	1
	Concrete	2	Groove end w/headwall	
		3	Groove end projecting	
2	Circular	1	Headwall	1
	CMP	2	Mitered to slope	
		3	Projecting	

3	Circular	A	Beveled ring, 45° bevels	1
		B	Beveled ring, 33.7° bevels	
8	Rectangular	1	30° to 75° wingwall flares	
	Box	2	90° and 15° wingwall flares	1
		3	0° wingwall flares	
9	Rectangular	1	90° headwall w/ 3/4" camfers	2
	Box	2	18° to 33.7° wingwall flare, d = .083D	
10	Rectangular	1	90° headwall w/ 3/4" camfers	2
	Box	2	90° headwall w/45° bevels	
		3	90° headwall w/33.7° bevels	

Constants for Inlet Control Design, continued

Chart Number	Shape and Material	Nomograph Scale	Inlet Edge Description	Equation Form
11	Rectangular	1	3/4" chamfers; 45° skewed headwall	2
	Box	2	3/4" chamfers; 30° skewed headwall	
		3	3/4" chamfers; 15° skewed headwall	
			45° bevels; 10° - 45° skewed headwall	
12	Rectangular	1	45° non-offset wingwall flares	2
	Box	2	18.4° non-offset wingwall flares	
	3/4" chamfers	3	18.4° non-offset wingwall flares	
			30° skewed barrel	
13	Rectangular	1	45° wingwall flares—offset	2
	Box	2	33.7° wingwall flares—offset	
	Top Bevels	3	18.4° wingwall flares—offset	
16-19	C M Boxes	1	90° headwall	1
		2	Thick wall projecting	
		3	Thin wall projecting	

Constants for Inlet Control Design, continued

Chart Number	Unsubmerged		Submerged	
	K	M	c	Y
1	.0098	2.0	.0398	0.67
	.0078	2.0	.0292	0.74
	.0045	2.0	.0317	0.69
2	.0078	2.0	.0379	0.69
	.0210	1.33	.0463	0.75
	.0340	1.5	.0553	0.54
3	.0018	2.5	.0300	0.74
	.0018	2.5	.0243	0.83
8	.026	1.0	.0385	0.81
	.061	0.75	.0400	0.80
	.061	0.75	.0423	0.82
9	.510	0.667	.0309	0.80
	.486	0.667	.0249	0.83
10	.515	0.667	.0375	0.79
	.495	0.667	.0314	0.82
	.486	0.667	.0252	0.865

Constants for Inlet Control Design, continued

Chart Number	Unsubmerged		Submerged	
	K	M	c	Y
11	.522	0.667	.0402	0.73
	.533	0.667	.0425	0.705
	.545	0.667	.04505	[0.68]
	.498	0.667	.0327	0.75
12	.497	0.667	.0339	0.803
	0.493	0.667	0.0361	0.806
	0.495	0.667	0.0386	0.71
13	0.497	0.667	0.0302	0.835
	0.495	0.667	0.0252	0.881
	0.493	0.667	0.0227	0.887
16-19	0.0083	2.0	0.0379	0.69
	0.0145	1.75	0.0419	0.64
	0.0340	1.5	0.0496	0.57

SOURCE: *Hydraulic Design of Highway Culverts, Hydraulic Design Series, No.5.* U.S. Department of Transporation, 1985.

Roughness Coefficients (Manning's n Values) for Selected Conduits

Surface	Manning's n Value
Reinforced concrete pipe	0.013
Reinforced concrete box	0.013
Vitrified clay pipe	0.013
Coated cast iron pipe	0.011
Uncoated cast iron pipe	0.012
Commercial wrought-iron, black pipe	0.013
Commercial wrought-iron, galvanized pipe	0.014
Smooth lockbar and welded "OD" pipe	0.011
Riveted and spiral steel	0.015
Corrugated metal pipe	0.0225
Corrugated aluminum pipe	0.0225
Corrugated metal pipe (paved invert)	0.020
Corrugated metal multi-plate pipe	0.035
Polyvinyl chloride (PVC) pipe	0.010

Entrance Loss Coefficients k_e

Box Culverts

Type of Structure and Design of Entrance	Coefficient
Headwall Parallel to Embankment (no wingwalls):	—
Square-edged on three edges	0.50
Three edges rounded to radius of 1/12 barrel dimension	0.20
Wingwalls at 15 to 45 degrees to Barrel:	—
Square-edged top corner	0.40
Top corner rounded to radius of 1/2 barrel dimension	0.20

Pipe Culverts

Type of Structure and Design of Entrance	Coefficient
Concrete Pipe Projecting from Fill (no headwall):	—
Socket end of pipe	0.20
Square cut end of pipe	0.50
Concrete Pipe with Headwall or Headwall and Wingwalls:	—
Socket end of pipe	0.20
Square cut end of pipe	0.50
Rounded entrance, with rounding radius = 1/12 of diameter	0.20
Corrugated Metal Pipe:	—
Projecting from fill (no headwall)	0.90
With headwall or headwall and wingwalls, square edge	0.50

SOURCE: *Hydraulic Design of Highway Culverts, Hydraulic Design Series, No. 5.* U.S. Department of Transportation, 1985.

Runoff Curve Numbers (Ave. Watershed Condition $I_a = 0.2S$

SCS developed a soil classification system consisting of four groups, identified by the letters A, B, C and D. Soil characteristics associated with each group are:

- Group A: deep sand, deep loess, aggregated silts
- Group B: shallow loess; sandy loam
- Group C: clay loams; shallow sandy loams; soils low in organic content; soils
- Group D: soils that swell significantly when wet; heavy plactic clays; certain saline soils

Land Use Description	Average (%) impervious	Curve Numbers for Hydrologic Soil Group			
		A	B	C	D
Fully developed urban areas (vegetation established)					
Lawns, open spaces, parks, golf courses, cemeteries, etc.					
Good condition; grass cover on 75% or more of the area		39	61	74	80
Fair condition; grass cover on 50% to 75% of the area		49	69	79	84
Poor condition; grass cover on 50% or less of the area	—	68	79	86	89
Paved parking lots, roof, driveways, etc.	—	98	98	98	98
Streets and Roads					
Paved with curbs and storm sewers		98	98	98	98
Gravel	—	76	85	89	91
Dirt		72	82	87	89
Paved with open ditches		83	89	92	93
Commercial and business areas	85	89	92	94	95
Industrial districts	72	81	88	91	93
Row houses, town houses and residential with lot sizes 1/8 acre or less	65	77	85	90	92

Cover			Curve Numbers for Hydrologic Soil Group			
Land Use	**Treatment of Practice**	**Hydrologic Conditions**	**A**	**B**	**C**	**D**
Residential: average lot size						
1/4 acre	38	61	75	83	87	
1/3 acre	30	57	72	81	86	
1/2 acre	25	54	70	80	85	
1 acre	20	51	68	79	84	
2 acre	12	46	65	77	82	
Developing urban areas c (no vegetation established Newly graded area	—	77	86	91	94	
Cultivated agricultural land						
Fallow	Straight row		77	86	91	94
	Conservation tillage	Poor	76	85	90	93
	Conservation tillage	Good	74	83	88	90
Row Crops	Straight row	Poor	72	81	88	91
	Straight row	Good	67	78	85	89
	Conservation tillage	Poor	70	80	87	90
	Conservation tillage	Good	64	75	82	85
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Contoured and	Poor	69	78	83	87
	conservation tillage	Good	64	74	81	85
	Contoured and terraces	Poor	66	74	80	82
	Contoured and terraces	Good	62	71	78	81
	Contoured and terraces	Poor	65	73	79	81
	and conservation tillage	Good	61	70	77	80

Cover			Curve Numbers for Hydrologic Soil Group			
Land Use	**Treatment of Practice**	**Hydrologic Conditions**	**A**	**B**	**C**	**D**
Small grain	Straight row	Poor	65	76	84	88
	Straight row	Good	63	75	83	87
	Conservation tillage	Poor	64	75	83	86
	Conservation tillage	Good	60	72	80	84
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	3	81	84
	Contoured and	Poor	62	73	81	84
	conservation tillage	Good	60	2	80	83
	Contoured and terraces	Poor	61	72	79	82
	Contoured and terraces	Good	59	70	78	81
	Contoured and terraces	Poor	60	71	78	81
	and conservation tillage	Good	58	69	77	80
Close-seeded legumes or rotation meadow	Straight row	Poor	66	77	85	89
	Straight row	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	Contoured and terraces	Poor	63	73	80	83
	Contoured and terraces	Good	51	67	76	80
Noncultivated agricultural land						
Pasture or range	No mechanical treatment	Poor	68	79	86	89
	No mechanical treatment	Fair	49	69	79	84
	No mechanical treatment	Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow	—	—	30	58	71	78
Forestland - grass or orchards - evergreen or deciduous	—	Poor	55	73	82	86
		Fair	44	65	76	82
		Good	32	8	72	79
Brush	—	Poor	48	67	77	83
		Good	20	48	65	73

Cover			Curve Numbers for Hydrologic Soil Group			
Land Use	Treatment of Practice	Hydrologic Conditions	A	B	C	D
Woods	—	Poor Fair Good	45 36 25	66 60 55	77 73 70	83 79 77
Farmsteads	—	—	59	74	82	86
Forest-range Herbaceous	—	Poor Fair Good	—	79 71 61	86 80 74	—
Oak - aspen	—	Poor Fair Good	—	65 47 30	74 57 41	—
Juniper - grass	—	Poor Fair Good	—	72 58 41	83 73 61	—
Sage - grass	—	Poor Fair Good	—	67 50 35	80 63 46	—

aFor land uses with impervious areas, curve numbers are computed assuming that 100% of runoff from impervious areas are directly connected to the drainage system. Pervious areas (lawn) are considered to be equivalent to lawns in good condition and the impervious areas have a CN of 98.

bIncludes paved streets.

cUse for the design of temporary measures during grading and construction. Impervious area percent for urban areas under development vary considerably.

dFor conservation tillage poor hydrologic condition, 5 to 20% of the surface is covered with residue (less than 750-lb/acre row crops or 300-lb/acre small grain).

eClose-drilled or broadcast.
For noncultivated agricultural land:
Poor hydrologic condition has less than 25% ground cover density.
Fair hydrologic condition has between 25 and 50% ground cover density.

Good hydrologic condition has more than 50% ground cover density.
For forest-range:
Poor hydrologic condition has less than 30% ground cover density.
Fair hydrologic condition has between 30 and 70% ground cover density.
Good hydrologic condition has more than 70% ground cover density.

SOURCE: *Hydraulic Analysis and Design*, Richard H. McCuen,1989.

Appendix B: References

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Appendix C: Default Layers

The following table contains a list of layers associated with each ***Watershed Modeling*** drawing.

Layer Name	Description
HYDRO 00X	Hydrograph Block and Description (#, Rp, Qp, Tp)
LU_XXXXXX	Land Use Library Layer
WB_XXXXXX	Watershed Library Layer

Graphical Default Layers

The follwing table contains a list of layers associated with each *Watershed Modeling* graphic.

Layer Name	Description
Basis	Graph title, outline rectangle, scale line, number
Coords	Coordinate X,Y value
Curvex	Hydrograph, unit hydrograph, structure curve line
Grid	Grid Line
Legend	Legend box, legend description

Appendix D: Time of Concentration (t_C)

Time of concentration, t_c, for a drainage area is defined as the time a drop of water takes to drain from the hydraulically most remote point in the watershed. It affects the shape and the peak discharge of the unit hydrograph and flood hydrograph. In general, higher and faster peak discharge is associated with smaller t_c.

Different methods are available for computing t_c for a drainage area. ***Watershed Modeling*** has two methods built into its programming structure to compute t_c, in addition to the user-defined option. These are the SCS Lag method and the TR-55 tabular method. A brief theory on each of these methods follow:

SCS Lag Method

Proposed by the Soil Conservation Services (SCS), this method uses the basin lag time based on the average land slope, curve number (CN) and the hydraulic length. From the known CN, the available storage, S, is computed using:

$$S = \frac{1000}{CN} - 10 \tag{D-1}$$

The basin lag is then estimated using:

$$Lag = \frac{L^{0.8} * (S+1)^{0.7}}{1900 * (s * 100)^{0.5}} \; hours \tag{D-2}$$

Where:
Lag = basin lag in hours
L = hydraulic length in feet
S = available storage
s = average slope of the drainage area in ft/ft

The time of concentration, t_c, for the drainage basin is then computed using:

$$t_c = 1.67 * Lag \quad (hours) \tag{D-3}$$

$$= (1.67 * Lag) * 60 \quad (minutes) \tag{D-4}$$

TR-55 Method

The TR-55 tabular method of computing t_c divides it into travel times for three different segments; namely sheet flow, shallow concentrated flow and channel flow. Travel times for each segment are computed and summed to arrive at the time of concentration for the drainage basin. For example:

$$t_c = t_{sf} + t_{scf} + t_{cf} \tag{D-5}$$

Where:
t_c =time of concentration for the drainage basin
t_{sf} =time of travel for sheet flow
t_{scf} =travel time for shallow concentrated flow
t_{cf} =travel time for channel flow

The units of t_c are the same as that of t_{sf}, t_{scf} and t_{cf}.

Sheet Flow

The flow over plane surfaces, which have depths of about 0.1 feet, are lumped into the sheet flow category. Using assumptions of:

- shallow, steady, uniform flow
- constant intensity rainfall excess
- 24-hour storm duration
- negligible effect of infiltration
- flow lengths less that 300 ft

TR-55 uses the kinematic solution to the Manning's equation to calculate t_{sf} as:

$$t_{sf} = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,(s)^{0.4}} \tag{D-6}$$

Where:
t_{sf} =sheet flow travel time, in hours
n =Manning's roughness coefficient for sheet flow (see *Appendix A—Reference Tables*)
L =sheet flow length (ft.)
P_2 =2 year, 24 hour rainfall (in.)
s =Slope of hydraulic grade line which is approximated as the land slope in ft/ft.

Shallow Concentrated Flow

TR-55 method assumes that the sheet flow becomes shallow concentrated flow after a maximum of 300 feet. The average velocity is taken as a function of water course slope and land use. The relationship is expressed as:

$$V = k\,(100s)^{0.5} \qquad \textbf{(D-7)}$$

Where:
- V =average velocity in ft/sec
- k =parameter, which is a function of land use (see *Appendix A—Reference Tables*)
- s =average land slope (ft/ft)

The travel time for shallow concentrated flow is then computed as:

$$t_{sc_f} = \frac{L}{(3600V)} \qquad \textbf{(D-8)}$$

Where:
- t_{sc_f} =time of travel for shallow concentrated flow, in hours
- L =flow length (ft)
- V =average velocity from equation E-7 in ft/sec

Channel Flow

TR-55 uses Manning's equation to determine the average velocity through channels. The Manning's equation is:

$$V = \frac{1.49}{n} R_h^{2/3} * s^{1/2} \qquad \textbf{(D-9)}$$

Where:
- V =average channel velocity in ft/sec
- n =Manning roughness coefficient for channel material (see *Appendix A—Reference Tables*)
- R_h =hydraulic radius (ft.)
- A =flow area (ft^2)
- P =wetted perimeter of the channel (ft)
- s =slope of the hydraulic grade line, assumed to be the channel slope in ft/ft

The travel time for channel flow, t_{c_f}, is then computed as:

$$t_{cf} = \frac{L}{3600V} \qquad \textbf{(D-10)}$$

Where:

t_{cf} =time of travel for channel flow, in hours
V =average flow velocity, in ft/sec
L =flow length, in feet

Equations E-6, E-7 and E-10 can now be used in equation E-5 to compute time of concentration in hours.

APPENDIX B

SCS RAINFALL DISTRIBUTIONS

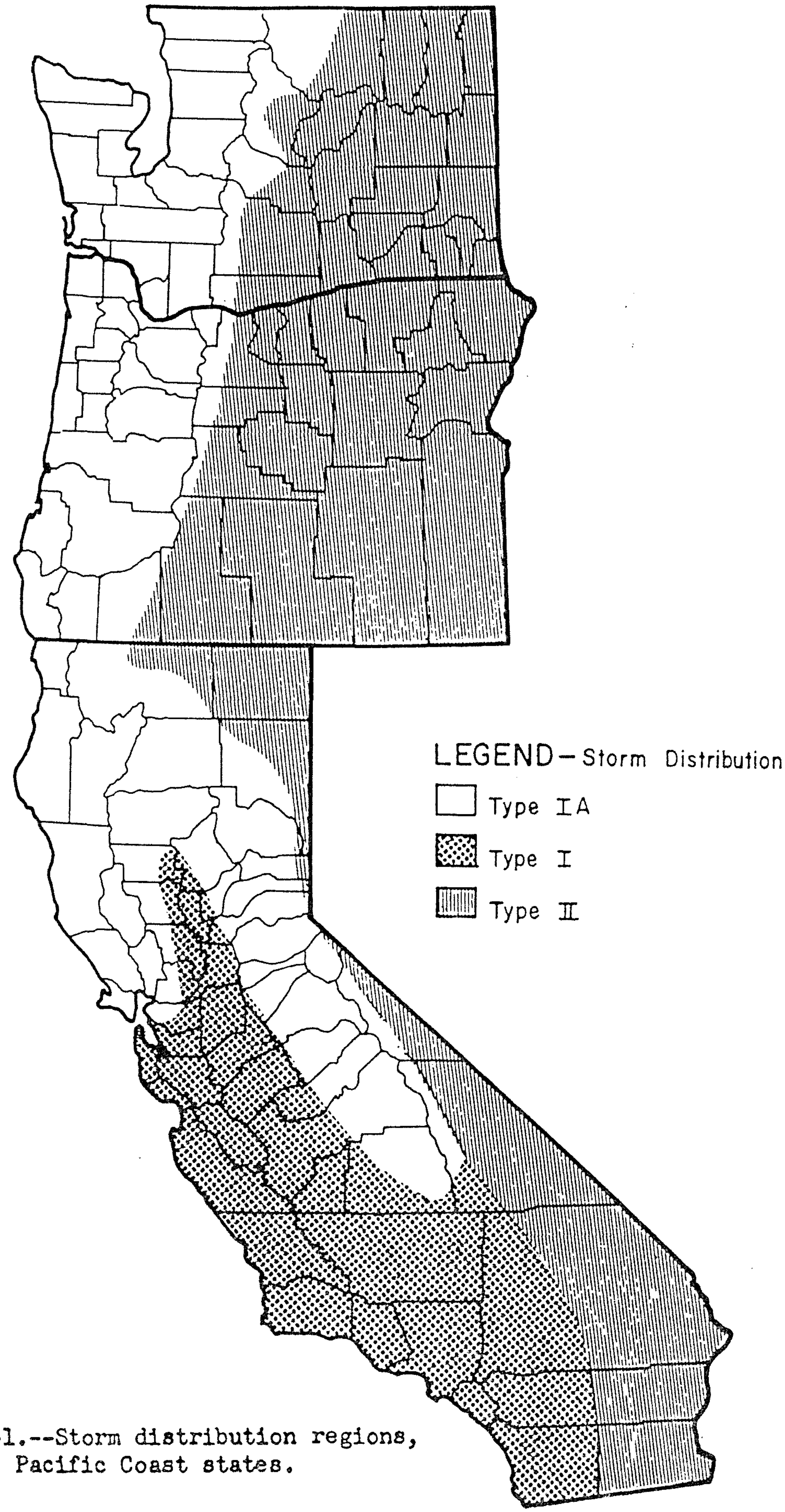

Figure D-1.--Storm distribution regions, Pacific Coast states.

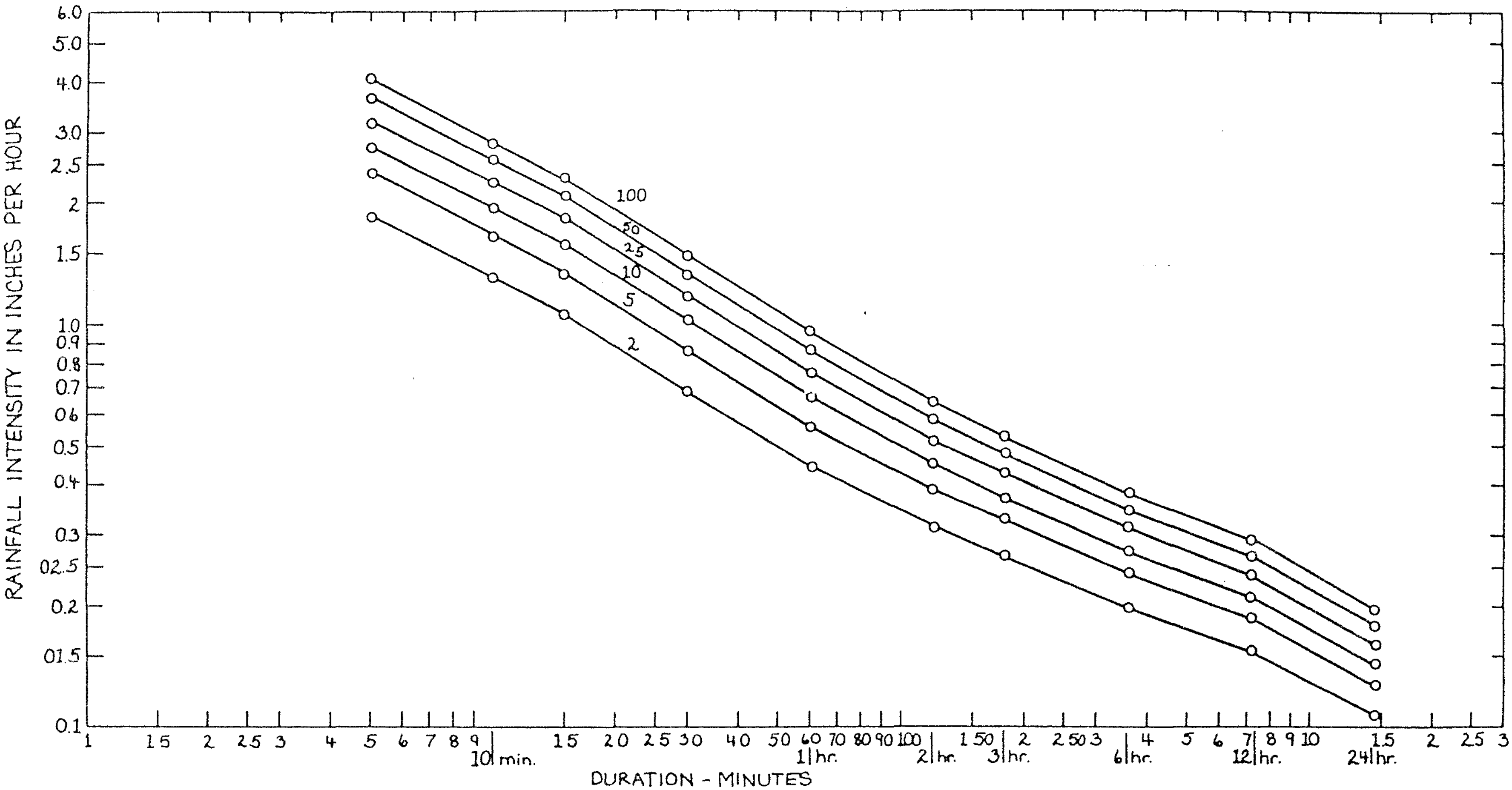

Figure D-3. Intensity-Duration-Frequency/Oregon City

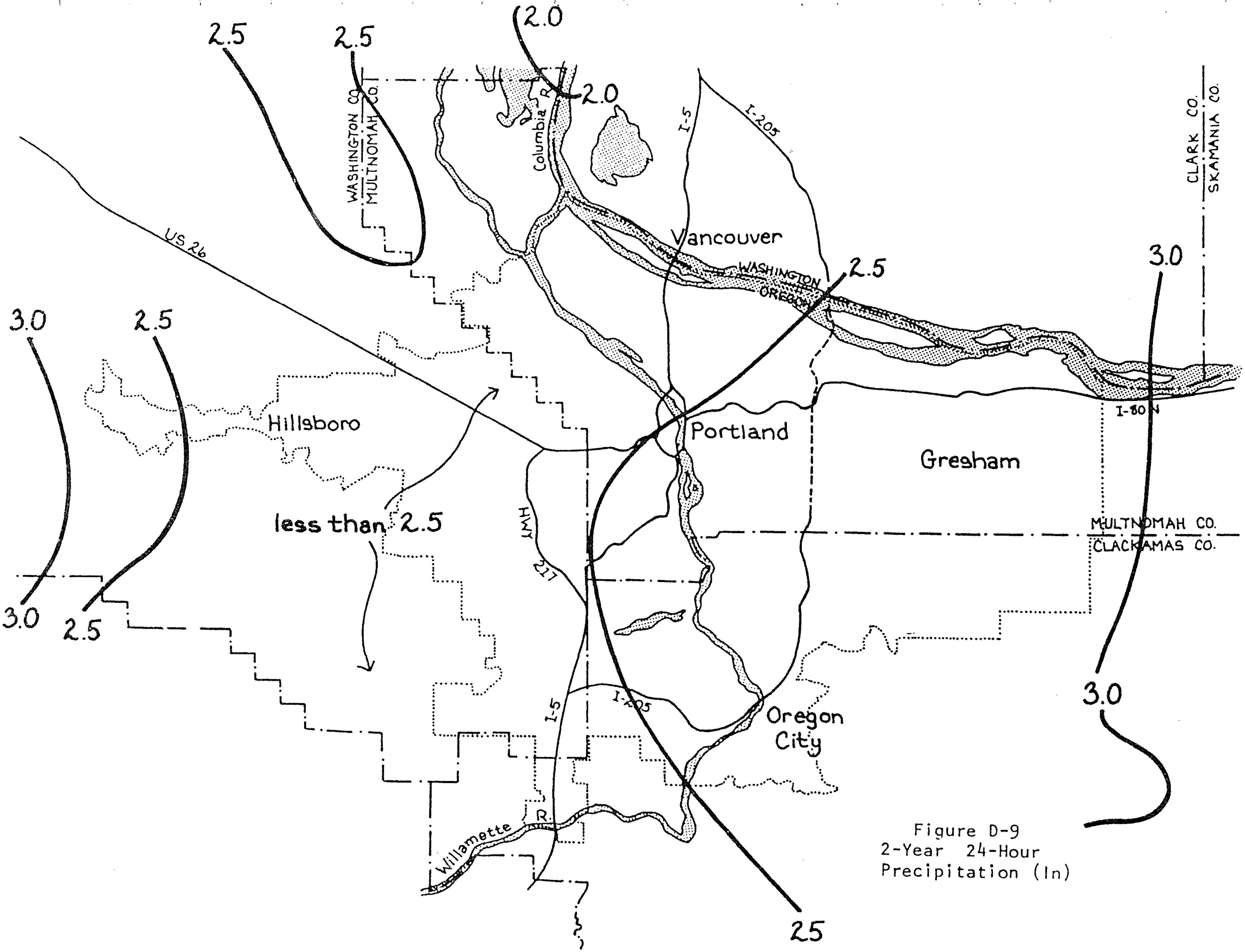

Figure D-9
2-Year 24-Hour
Precipitation (In)

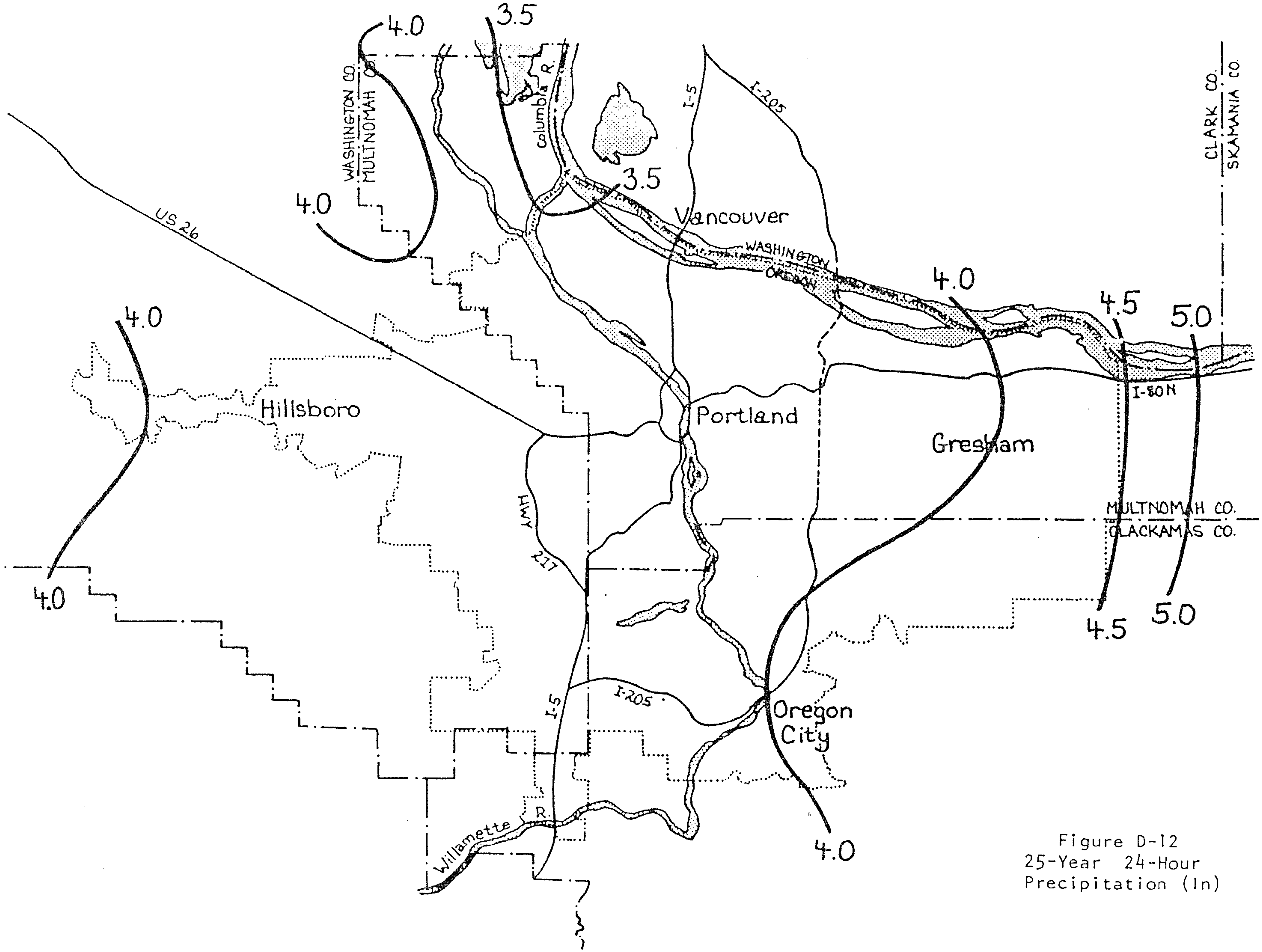

Figure D-12
25-Year 24-Hour
Precipitation (In)

APPENDIX C

FLOOD HYDROGRAPH SUMMARIES & GRAPHS

The following Flood Hydrograph Summaries provide a synopsis of the modeling assumptions and resultant calculated flowrates for each of the modeled subbasins, as well as combined hydrograph data and storage routing results, if applicable.

HYDROGRAPH REPORT

RECORD NUMBER : 1
TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE10

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	20.50 (cfs)
Volume....................................	=	10.88 (acft)
Time Interval.............................	=	10.00 (min)
Time to Peak..............................	=	490.00 (min)
Time of Base..............................	=	1850.00 (min)
Multiplication factor.....................	=	1.00

[BASIN DESCRIPTION]

Watershed Area............................	=	46.81 (ac)
Curve Number..............................	=	85

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n)............	=	0.25000
Flow Length (L)..........................	=	300.00 (ft)
2-yr 24-hr Rainfall (R)................	=	2.60 (in)
Land Slope (S)...........................	=	0.03000
Travel Time of Sheet Flow................	=	33.49 (min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	0.70000
Watercourse Slope (S).....................	=	0.03000
Velocity (V).............................	=	1.21 (ft/s)
Flow Length (L)..........................	=	150.00 (ft)
Travel Time of Shallow Flow..............	=	2.06 (min)

CHANNEL FLOW

Hydraulic Radius (R).....................	=	0.50 (ft)
Channel Slope (S)........................	=	0.01000
Manning's Roughness Coef. (n)............	=	0.01300
Channel Velocity (V).....................	=	7.22 (ft/s)
Flow Length (L)..........................	=	1800.00 (ft)
Travel Time of Shallow Flow..............	=	4.15 (min)

TIME OF CONCENTRATION

Time of Concentration....................	=	39.71 (min)

[RAINFALL DESCRIPTICN]

Distribution Type........................	=	SCS IA
Total Precipitation......................	=	4.00 (in)
Return Period............................	=	25 (yr)
Storm Duration...........................	=	24.00 (hr)
Impervious Fraction......................	=	0.25000

HYDROGRAPH REPORT

RECORD NUMBER : 2
TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE20

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	15.75 (cfs)
Volume....................................	=	11.67 (acft)
Time Interval.............................	=	10.00 (min)
Time to Peak..............................	=	500.00 (min)
Time of Base..............................	=	2290.00 (min)
Multiplication factor.....................	=	1.00

[BASIN DESCRIPTION]

Watershed Area............................	=	55.12 (ac)
Curve Number..............................	=	85

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n).............	=	0.25000
Flow Length (L)...........................	=	300.00 (ft)
2-yr 24-hr Rainfall (R).................	=	2.60 (in)
Land Slope (S)............................	=	0.01000
Travel Time of Sheet Flow.................	=	68.58 (min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	0.70000
Watercourse Slope (S).....................	=	0.00000
Velocity (V)..............................	=	0.00 (ft/s)
Flow Length (L)...........................	=	700.00 (ft)
Travel Time of Shallow Flow...............	=	5.65 (min)

CHANNEL FLOW

Hydraulic Radius (R)......................	=	1.90 (ft)
Channel Slope (S).........................	=	0.01000
Manning's Roughness Coef. (n).............	=	0.10000
Channel Velocity (V)......................	=	2.29 (ft/s)
Flow Length (L)...........................	=	800.00 (ft)
Travel Time of Shallow Flow...............	=	5.83 (min)

TIME OF CONCENTRATION

Time of Concentration.....................	=	80.06 (min)

[RAINFALL DESCRIPTION]

Distribution Type.........................	=	SCS IA
Total Precipitation.......................	=	4.00 (in)
Return Period.............................	=	25 (yr)
Storm Duration............................	=	24.00 (hr)
Impervious Fraction.......................	=	0.06000

HYDROGRAPH REPORT

RECORD NUMBER : 3
TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE30

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	12.43 (cfs)
Volume....................................	=	10.15 (acft)
Time Interval.............................	=	10.00 (min)
Time to Peak..............................	=	510.00 (min)
Time of Base..............................	=	2490.00 (min)
Multiplication factor.....................	=	1.00

[BASIN DESCRIPTION]

Watershed Area............................	=	45.84 (ac)
Curve Number..............................	=	85

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n)............	=	0.25000	
Flow Length (L)..........................	=	400.00	(ft)
2-yr 24-hr Rainfall (R)................	=	2.60	(in)
Land Slope (S)...........................	=	0.01000	
Travel Time of Sheet Flow................	=	65.43	(min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	0.70000	
Watercourse Slope (S)....................	=	0.01000	
Velocity (V).............................	=	0.70	(ft/s)
Flow Length (L)..........................	=	900.00	(ft)
Travel Time of Shallow Flow..............	=	21.43	(min)

CHANNEL FLOW

Hydraulic Radius (R).....................	=	1.90	(ft)
Channel Slope (S)........................	=	0.00000	
Manning's Roughness Coef. (n)............	=	0.10000	
Channel Velocity (V).....................	=	0.00	(ft/s)
Flow Length (L)..........................	=	600.00	(ft)
Travel Time of Shallow Flow..............	=	13.04	(min)

TIME OF CONCENTRATION

Time of Concentration....................	=	99.90	(min)

[RAINFALL DESCRIPTION]

Distribution Type........................	=	SCS IA	
Total Precipitation......................	=	4.00	(in)
Return Period............................	=	25	(yr)
Storm Duration...........................	=	24.00	(hr)
Impervious Fraction......................	=	0.15000	

HYDROGRAPH REPORT

RECORD NUMBER : 4
TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE40

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	23.91	(cfs)
Volume....................................	=	15.34	(acft)
Time Interval.............................	=	10.00	(min)
Time to Peak..............................	=	500.00	(min)
Time of Base..............................	=	2080.00	(min)
Multiplication factor.....................	=	1.00	

[BASIN DESCRIPTION]

Watershed Area............................	=	69.37	(ac)
Curve Number..............................	=	84	

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n)............	=	0.25000	
Flow Length (L)..........................	=	300.00	(ft)
2-yr 24-hr Rainfall (R)................	=	2.60	(in)
Land Slope (S)..........................	=	0.02000	
Travel Time of Sheet Flow................	=	39.39	(min)

SHALLOW FLOW

K_Coef (surface description) (K).........	=	0.70000	
Watercourse Slope (S)....................	=	0.03000	
Velocity (V).............................	=	1.21	(ft/s)
Flow Length (L)..........................	=	300.00	(ft)
Travel Time of Shallow Flow..............	=	4.12	(min)

CHANNEL FLOW

Hydraulic Radius (R).....................	=	1.90	(ft)
Channel Slope (S)........................	=	0.01000	
Manning's Roughness Coef. (n)............	=	0.10000	
Channel Velocity (V).....................	=	2.29	(ft/s)
Flow Length (L)..........................	=	2200.00	(ft)
Travel Time of Shallow Flow..............	=	16.04	(min)

TIME OF CONCENTRATION

Time of Concentration....................	=	59.56	(min)

[RAINFALL DESCRIPTION]

Distribution Type........................	=	SCS IA	
Total Precipitation......................	=	4.00	(in)
Return Period............................	=	25	(yr)
Storm Duration...........................	=	24.00	(hr)
Impervious Fraction......................	=	0.20000	

HYDROGRAPH REPORT

RECORD NUMBER : 5
TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE50

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	25.04	(cfs)
Volume....................................	=	24.83	(acft)
Time Interval.............................	=	10.00	(min)
Time to Peak..............................	=	540.00	(min)
Time of Base..............................	=	3120.00	(min)
Multiplication factor.....................	=	1.00	

[BASIN DESCRIPTION]

Watershed Area............................	=	114.69	(ac)
Curve Number..............................	=	84	

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n).............	=	0.25000	
Flow Length (L)...........................	=	1100.00	(ft)
2-yr 24-hr Rainfall (R).................	=	2.60	(in)
Land Slope (S)............................	=	0.02000	
Travel Time of Sheet Flow.................	=	111.38	(min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	0.70000	
Watercourse Slope (S).....................	=	0.01000	
Velocity (V)..............................	=	0.70	(ft/s)
Flow Length (L)...........................	=	1000.00	(ft)
Travel Time of Shallow Flow...............	=	23.81	(min)

CHANNEL FLOW

Hydraulic Radius (R)......................	=	1.90	(ft)
Channel Slope (S).........................	=	0.02000	
Manning's Roughness Coef. (n).............	=	0.10000	
Channel Velocity (V)......................	=	3.23	(ft/s)
Flow Length (L)...........................	=	2200.00	(ft)
Travel Time of Shallow Flow...............	=	11.34	(min)

TIME OF CONCENTRATION

Time of Concentration.....................	=	146.54	(min)

[RAINFALL DESCRIPTION]

Distribution Type.........................	=	SCS IA	
Total Precipitation.......................	=	4.00	(in)
Return Period.............................	=	25	(yr)
Storm Duration............................	=	24.00	(hr)
Impervious Fraction.......................	=	0.16000	

HYDROGRAPH REPORT

RECORD NUMBER : 6
TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE60

[HYDROGRAPH INFORMATION]

Peak Discharge	=	22.28 (cfs)
Volume	=	18.01 (acft)
Time Interval	=	10.00 (min)
Time to Peak	=	520.00 (min)
Time of Base	=	2460.00 (min)
Multiplication factor	=	1.00

[BASIN DESCRIPTION]

Watershed Area	=	88.92 (ac)
Curve Number	=	84

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n).............	=	0.25000
Flow Length (L)...........................	=	500.00 (ft)
2-yr 24-hr Rainfall (R).................	=	2.60 (in)
Land Slope (S)............................	=	0.02000
Travel Time of Sheet Flow.................	=	64.81 (min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	0.70000
Watercourse Slope (S).....................	=	0.01000
Velocity (V)..............................	=	0.70 (ft/s)
Flow Length (L)...........................	=	1000.00 (ft)
Travel Time of Shallow Flow...............	=	23.81 (min)

CHANNEL FLOW

Hydraulic Radius (R)......................	=	1.90 (ft)
Channel Slope (S).........................	=	0.02000
Manning's Roughness Coef. (n).............	=	0.10000
Channel Velocity (V)......................	=	3.23 (ft/s)
Flow Length (L)...........................	=	700.00 (ft)
Travel Time of Shallow Flow...............	=	3.61 (min)

TIME OF CONCENTRATION

Time of Concentration.....................	=	92.23 (min)

[RAINFALL DESCRIPTION]

Distribution Type.........................	=	SCS IA
Total Precipitation.......................	=	4.00 (in)
Return Period.............................	=	25 (yr)
Storm Duration............................	=	24.00 (hr)
Impervious Fraction.......................	=	0.04000

HYDROGRAPH REPORT

RECORD NUMBER : 7
TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE70

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	13.01 (cfs)
Volume....................................	=	9.77 (acft)
Time Interval.............................	=	10.00 (min)
Time to Peak..............................	=	510.00 (min)
Time of Base..............................	=	2270.00 (min)
Multiplication factor.....................	=	1.00

[BASIN DESCRIPTION]

Watershed Area............................	=	48.26 (ac)
Curve Number..............................	=	84

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n).............	=	0.25000	
Flow Length (L)...........................	=	400.00	(ft)
2-yr 24-hr Rainfall (R).................	=	2.60	(in)
Land Slope (S)............................	=	0.02000	
Travel Time of Sheet Flow.................	=	55.63	(min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	0.70000	
Watercourse Slope (S).....................	=	0.02000	
Velocity (V)..............................	=	0.99	(ft/s)
Flow Length (L)...........................	=	800.00	(ft)
Travel Time of Shallow Flow...............	=	13.47	(min)

CHANNEL FLOW

Hydraulic Radius (R)......................	=	1.90	(ft)
Channel Slope (S).........................	=	0.02000	
Manning's Roughness Coef. (n).............	=	0.10000	
Channel Velocity (V)......................	=	3.23	(ft/s)
Flow Length (L)...........................	=	2000.00	(ft)
Travel Time of Shallow Flow...............	=	10.31	(min)

TIME OF CONCENTRATION

Time of Concentration.....................	=	79.41	(min)

[RAINFALL DESCRIPTION]

Distribution Type.........................	=	SCS IA	
Total Precipitation.......................	=	4.00	(in)
Return Period.............................	=	25	(yr)
Storm Duration............................	=	24.00	(hr)
Impervious Fraction.......................	=	0.04000	

HYDROGRAPH REPORT

RECORD NUMBER : 8
TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE80

[HYDROGRAPH INFORMATION]

Peak Discharge...........................	=	37.64	(cfs)
Volume..................................	=	28.02	(acft)
Time Interval............................	=	10.00	(min)
Time to Peak.............................	=	500.00	(min)
Time of Base.............................	=	2350.00	(min)
Multiplication factor....................	=	1.00	

[BASIN DESCRIPTION]

Watershed Area...........................	=	133.74	(ac)
Curve Number.............................	=	84	

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n)............	=	0.25000	
Flow Length (L)..........................	=	400.00	(ft)
2-yr 24-hr Rainfall (R)................	=	2.60	(in)
Land Slope (S)...........................	=	0.01000	
Travel Time of Sheet Flow................	=	58.91	(min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	0.70000	
Watercourse Slope (S)....................	=	0.01000	
Velocity (V).............................	=	0.70	(ft/s)
Flow Length (L)..........................	=	300.00	(ft)
Travel Time of Shallow Flow..............	=	7.14	(min)

CHANNEL FLOW

Hydraulic Radius (R).....................	=	1.90	(ft)
Channel Slope (S)........................	=	0.02000	
Manning's Roughness Coef. (n)............	=	0.10000	
Channel Velocity (V).....................	=	3.23	(ft/s)
Flow Length (L)..........................	=	2600.00	(ft)
Travel Time of Shallow Flow..............	=	13.41	(min)

TIME OF CONCENTRATION

Time of Concentration....................	=	79.46	(min)

[RAINFALL DESCRIPTION]

Distribution Type........................	=	SCS IA	
Total Precipitation......................	=	4.00	(in)
Return Period............................	=	25	(yr)
Storm Duration...........................	=	24.00	(hr)
Impervious Fraction......................	=	0.10000	

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HYDROGRAPH REPORT

RECORD NUMBER : 9
TYPE : COMBINE
DESCRIPTION : COMB-EX

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	168.18 (cfs)
Volume....................................	=	128.66 (acft)
Time Interval.............................	=	10.00 (min)
Time to Peak..............................	=	500.00 (min)
Time of Base..............................	=	3120.00 (min)

[COMBINE HYDROGRAPH RECORD #]

HYDROGRAPH # 1 TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE10

Peak Discharge........................	=	20.50 (cfs)
Time to Peak..........................	=	490.00 (min)
Time Interval.........................	=	10.00 (min)

HYDROGRAPH # 2 TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE20

Peak Discharge........................	=	15.75 (cfs)
Time to Peak..........................	=	500.00 (min)
Time Interval.........................	=	10.00 (min)

HYDROGRAPH # 3 TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE30

Peak Discharge........................	=	12.43 (cfs)
Time to Peak..........................	=	510.00 (min)
Time Interval.........................	=	10.00 (min)

HYDROGRAPH # 4 TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE40

Peak Discharge........................	=	23.91 (cfs)
Time to Peak..........................	=	500.00 (min)
Time Interval.........................	=	10.00 (min)

HYDROGRAPH # 5 TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE50

Peak Discharge........................	=	25.04 (cfs)
Time to Peak..........................	=	540.00 (min)
Time Interval.........................	=	10.00 (min)

HYDROGRAPH # 6 TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE60

Peak Discharge........................	=	22.28 (cfs)
Time to Peak..........................	=	520.00 (min)
Time Interval.........................	=	10.00 (min)

HYDROGRAPH # 7 TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE70

Peak Discharge........................	=	13.01 (cfs)
Time to Peak..........................	=	510.00 (min)
Time Interval.........................	=	10.00 (min)

HYDROGRAPH # 8 TYPE : SANTA BARBARA
DESCRIPTION : Existing-25-SE80

Peak Discharge........................	=	37.64 (cfs)
Time to Peak..........................	=	500.00 (min)
Time Interval.........................	=	10.00 (min)

HYDROGRAPH REPORT

RECORD NUMBER : 1
TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE10

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	31.74	(cfs)
Volume....................................	=	11.62	(acft)
Time Interval.............................	=	5.00	(min)
Time to Peak..............................	=	480.00	(min)
Time of Base..............................	=	1575.00	(min)
Multiplication factor.....................	=	1.00	

[BASIN DESCRIPTION]

Watershed Area............................	=	46.81	(ac)
Curve Number..............................	=	87	

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n)............	=	0.04000	
Flow Length (L)..........................	=	300.00	(ft)
2-yr 24-hr Rainfall (R)................	=	2.60	(in)
Land Slope (S)..........................	=	0.03000	
Travel Time of Sheet Flow................	=	7.73	(min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	1.50000	
Watercourse Slope (S)....................	=	0.03000	
Velocity (V).............................	=	2.60	(ft/s)
Flow Length (L)..........................	=	150.00	(ft)
Travel Time of Shallow Flow..............	=	0.96	(min)

CHANNEL FLOW

Hydraulic Radius (R).....................	=	0.50	(ft)
Channel Slope (S)........................	=	0.01000	
Manning's Roughness Coef. (n)............	=	0.01300	
Channel Velocity (V).....................	=	7.22	(ft/s)
Flow Length (L)..........................	=	1800.00	(ft)
Travel Time of Shallow Flow..............	=	4.15	(min)

TIME OF CONCENTRATION

Time of Concentration....................	=	12.85	(min)

[RAINFALL DESCRIPTION]

Distribution Type........................	=	SCS IA	
Total Precipitation......................	=	4.00	(in)
Return Period............................	=	25	(yr)
Storm Duration...........................	=	24.00	(hr)
Impervious Fraction......................	=	0.30000	

HYDROGRAPH REPORT

RECORD NUMBER : 2
TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE20

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	29.59	(cfs)
Volume....................................	=	13.43	(acft)
Time Interval.............................	=	10.00	(min)
Time to Peak..............................	=	490.00	(min)
Time of Base..............................	=	1720.00	(min)
Multiplication factor.....................	=	1.00	

[BASIN DESCRIPTION]

Watershed Area............................	=	55.12	(ac)
Curve Number..............................	=	87	

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n)............	=	0.04000	
Flow Length (L)..........................	=	300.00	(ft)
2-yr 24-hr Rainfall (R)................	=	2.60	(in)
Land Slope (S)...........................	=	0.01000	
Travel Time of Sheet Flow................	=	15.83	(min)

SHALLOW FLOW

K_Coef (surface description) (K).........	=	1.50000	
Watercourse Slope (S)....................	=	0.03000	
Velocity (V).............................	=	2.60	(ft/s)
Flow Length (L)..........................	=	300.00	(ft)
Travel Time of Shallow Flow..............	=	1.92	(min)

CHANNEL FLOW

Hydraulic Radius (R).....................	=	1.90	(ft)
Channel Slope (S)........................	=	0.01000	
Manning's Roughness Coef. (n)............	=	0.10000	
Channel Velocity (V).....................	=	2.29	(ft/s)
Flow Length (L)..........................	=	1200.00	(ft)
Travel Time of Shallow Flow..............	=	8.75	(min)

TIME OF CONCENTRATION

Time of Concentration....................	=	26.51	(min)

[RAINFALL DESCRIPTION]

Distribution Type........................	=	SCS IA	
Total Precipitation......................	=	4.00	(in)
Return Period............................	=	25	(yr)
Storm Duration...........................	=	24.00	(hr)
Impervious Fraction......................	=	0.25000	

HYDROGRAPH REPORT

RECORD NUMBER : 3
TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE30

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	28.23	(cfs)
Volume....................................	=	11.38	(acft)
Time Interval.............................	=	5.00	(min)
Time to Peak..............................	=	480.00	(min)
Time of Base..............................	=	1635.00	(min)
Multiplication factor.....................	=	1.00	

[BASIN DESCRIPTION]

Watershed Area............................	=	45.84	(ac)
Curve Number..............................	=	87	

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n)............	=	0.04000	
Flow Length (L)..........................	=	300.00	(ft)
2-yr 24-hr Rainfall (R)................	=	2.60	(in)
Land Slope (S)...........................	=	0.01000	
Travel Time of Sheet Flow................	=	12.00	(min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	1.50000	
Watercourse Slope (S)....................	=	0.01000	
Velocity (V).............................	=	1.50	(ft/s)
Flow Length (L)..........................	=	300.00	(ft)
Travel Time of Shallow Flow..............	=	3.33	(min)

CHANNEL FLOW

Hydraulic Radius (R).....................	=	0.50	(ft)
Channel Slope (S)........................	=	0.01000	
Manning's Roughness Coef. (n)............	=	0.01300	
Channel Velocity (V).....................	=	7.22	(ft/s)
Flow Length (L)..........................	=	1500.00	(ft)
Travel Time of Shallow Flow..............	=	3.46	(min)

TIME OF CONCENTRATION

Time of Concentration....................	=	18.79	(min)

[RAINFALL DESCRIPTION]

Distribution Type........................	=	SCS IA	
Total Precipitation......................	=	4.00	(in)
Return Period............................	=	25	(yr)
Storm Duration...........................	=	24.00	(hr)
Impervious Fraction......................	=	0.30000	

HYDROGRAPH REPORT

RECORD NUMBER : 4
TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE40

HYDROGRAPH INFORMATION]

Peak Discharge............................	=	36.48	(cfs)
Volume....................................	=	16.50	(acft)
Time Interval.............................	=	5.00	(min)
Time to Peak..............................	=	485.00	(min)
Time of Base..............................	=	1730.00	(min)
Multiplication factor.....................	=	1.00	

BASIN DESCRIPTION]

Watershed Area............................	=	69.37	(ac)
Curve Number..............................	=	86	

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n)............	=	0.04000	
Flow Length (L)..........................	=	300.00	(ft)
2-yr 24-hr Rainfall (R)................	=	2.60	(in)
Land Slope (S)...........................	=	0.02000	
Travel Time of Sheet Flow................	=	9.09	(min)

SHALLOW FLOW

K_Coef (surface description) (K).........	=	1.50000	
Watercourse Slope (S)....................	=	0.03000	
Velocity (V).............................	=	2.60	(ft/s)
Flow Length (L)..........................	=	300.00	(ft)
Travel Time of Shallow Flow..............	=	1.92	(min)

CHANNEL FLOW

Hydraulic Radius (R).....................	=	1.90	(ft)
Channel Slope (S)........................	=	0.01000	
Manning's Roughness Coef. (n)............	=	0.10000	
Channel Velocity (V).....................	=	2.29	(ft/s)
Flow Length (L)..........................	=	2200.00	(ft)
Travel Time of Shallow Flow..............	=	16.04	(min)

TIME OF CONCENTRATION

Time of Concentration....................	=	27.06	(min)

[RAINFALL DESCRIPTION]

Distribution Type........................	=	SCS IA	
Total Precipitation......................	=	4.00	(in)
Return Period............................	=	25	(yr)
Storm Duration...........................	=	24.00	(hr)
Impervious Fraction......................	=	0.25000	

HYDROGRAPH REPORT

RECORD NUMBER : 5
TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE50

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	57.16	(cfs)
Volume....................................	=	27.29	(acft)
Time Interval.............................	=	5.00	(min)
Time to Peak..............................	=	485.00	(min)
Time of Base..............................	=	1795.00	(min)
Multiplication factor.....................	=	1.00	

[BASIN DESCRIPTION]

Watershed Area............................	=	114.69	(ac)
Curve Number..............................	=	86	

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n).............	=	0.04000	
Flow Length (L)...........................	=	300.00	(ft)
2-yr 24-hr Rainfall (R).................	=	2.60	(in)
Land Slope (S)............................	=	0.02000	
Travel Time of Sheet Flow.................	=	9.09	(min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	1.50000	
Watercourse Slope (S).....................	=	0.01000	
Velocity (V)..............................	=	1.50	(ft/s)
Flow Length (L)...........................	=	300.00	(ft)
Travel Time of Shallow Flow...............	=	3.33	(min)

CHANNEL FLOW

Hydraulic Radius (R)......................	=	1.90	(ft)
Channel Slope (S).........................	=	0.02000	
Manning's Roughness Coef. (n).............	=	0.10000	
Channel Velocity (V)......................	=	3.23	(ft/s)
Flow Length (L)...........................	=	3700.00	(ft)
Travel Time of Shallow Flow...............	=	19.08	(min)

TIME OF CONCENTRATION

Time of Concentration.....................	=	31.50	(min)

[RAINFALL DESCRIPTION]

Distribution Type.........................	=	SCS IA	
Total Precipitation.......................	=	4.00	(in)
Return Period.............................	=	25	(yr)
Storm Duration............................	=	24.00	(hr)
Impervious Fraction.......................	=	0.25000	

HYDROGRAPH REPORT

RECORD NUMBER : 6
TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE60

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	54.61 (cfs)
Volume....................................	=	21.16 (acft)
Time Interval.............................	=	5.00 (min)
Time to Peak..............................	=	480.00 (min)
Time of Base..............................	=	1615.00 (min)
Multiplication factor.....................	=	1.00

[BASIN DESCRIPTION]

Watershed Area............................	=	88.92 (ac)
Curve Number..............................	=	86

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n)............	=	0.04000	
Flow Length (L)..........................	=	300.00	(ft)
2-yr 24-hr Rainfall (R)................	=	2.60	(in)
Land Slope (S)...........................	=	0.02000	
Travel Time of Sheet Flow................	=	9.94	(min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	1.50000	
Watercourse Slope (S)....................	=	0.01000	
Velocity (V).............................	=	1.50	(ft/s)
Flow Length (L)..........................	=	300.00	(ft)
Travel Time of Shallow Flow..............	=	3.33	(min)

CHANNEL FLOW

Hydraulic Radius (R).....................	=	0.50	(ft)
Channel Slope (S)........................	=	0.02000	
Manning's Roughness Coef. (n)............	=	0.01300	
Channel Velocity (V).....................	=	10.21	(ft/s)
Flow Length (L)..........................	=	1600.00	(ft)
Travel Time of Shallow Flow..............	=	2.61	(min)

TIME OF CONCENTRATION

Time of Concentration....................	=	15.89	(min)

[RAINFALL DESCRIPTION]

Distribution Type........................	=	SCS IA	
Total Precipitation......................	=	4.00	(in)
Return Period............................	=	25	(yr)
Storm Duration...........................	=	24.00	(hr)
Impervious Fraction......................	=	0.25000	

HYDROGRAPH REPORT

RECORD NUMBER : 7
TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE70

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	25.73	(cfs)
Volume....................................	=	11.48	(acft)
Time Interval.............................	=	5.00	(min)
Time to Peak..............................	=	485.00	(min)
Time of Base..............................	=	1710.00	(min)
Multiplication factor.....................	=	1.00	

[BASIN DESCRIPTION]

Watershed Area............................	=	48.26	(ac)
Curve Number..............................	=	86	

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n)............	=	0.04000	
Flow Length (L).........................	=	300.00	(ft)
2-yr 24-hr Rainfall (R)................	=	2.60	(in)
Land Slope (S)..........................	=	0.02000	
Travel Time of Sheet Flow................	=	10.20	(min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	1.50000	
Watercourse Slope (S).....................	=	0.02000	
Velocity (V).............................	=	2.12	(ft/s)
Flow Length (L).........................	=	300.00	(ft)
Travel Time of Shallow Flow..............	=	2.36	(min)

CHANNEL FLOW

Hydraulic Radius (R).....................	=	1.90	(ft)
Channel Slope (S).........................	=	0.02000	
Manning's Roughness Coef. (n)............	=	0.10000	
Channel Velocity (V).....................	=	3.23	(ft/s)
Flow Length (L).........................	=	2600.00	(ft)
Travel Time of Shallow Flow..............	=	13.41	(min)

TIME OF CONCENTRATION

Time of Concentration....................	=	25.96	(min)

[RAINFALL DESCRIPTION]

Distribution Type........................	=	SCS IA	
Total Precipitation......................	=	4.00	(in)
Return Period............................	=	25	(yr)
Storm Duration...........................	=	24.00	(hr)
Impervious Fraction......................	=	0.25000	

HYDROGRAPH REPORT

RECORD NUMBER : 8
TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE80

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	75.71	(cfs)
Volume....................................	=	31.82	(acft)
Time Interval.............................	=	5.00	(min)
Time to Peak..............................	=	485.00	(min)
Time of Base..............................	=	1680.00	(min)
Multiplication factor.....................	=	1.00	

[BASIN DESCRIPTION]

Watershed Area............................	=	133.74	(ac)
Curve Number..............................	=	86	

[TIME CONCENTRATION -- TR-55]

SHEET FLOW

Manning's Roughness Coef. (n)............	=	0.04000	
Flow Length (L)..........................	=	400.00	(ft)
2-yr 24-hr Rainfall (R)................	=	2.60	(in)
Land Slope (S)...........................	=	0.01000	
Travel Time of Sheet Flow................	=	13.60	(min)

SHALLOW FLOW

K_Coef (surface description) (K)..........	=	1.50000	
Watercourse Slope (S)....................	=	0.01000	
Velocity (V).............................	=	1.50	(ft/s)
Flow Length (L)..........................	=	300.00	(ft)
Travel Time of Shallow Flow..............	=	3.33	(min)

CHANNEL FLOW

Hydraulic Radius (R).....................	=	0.50	(ft)
Channel Slope (S)........................	=	0.02000	
Manning's Roughness Coef. (n)............	=	0.01300	
Channel Velocity (V).....................	=	10.21	(ft/s)
Flow Length (L)..........................	=	2600.00	(ft)
Travel Time of Shallow Flow..............	=	4.24	(min)

TIME OF CONCENTRATION

Time of Concentration....................	=	21.18	(min)

[RAINFALL DESCRIPTION]

Distribution Type........................	=	SCS IA	
Total Precipitation......................	=	4.00	(in)
Return Period............................	=	25	(yr)
Storm Duration...........................	=	24.00	(hr)
Impervious Fraction......................	=	0.25000	

HYDROGRAPH REPORT

RECORD NUMBER : 9
TYPE : COMBINE
DESCRIPTION : 10+20+30+40

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	124.09 (cfs)
Volume...................................	=	52.93 (acft)
Time Interval............................	=	5.00 (min)
Time to Peak.............................	=	485.00 (min)
Time of Base.............................	=	1730.00 (min)

[COMBINE HYDROGRAPH RECORD #]

HYDROGRAPH # 1 TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE10

Peak Discharge.......................	=	31.74 (cfs)
Time to Peak.........................	=	480.00 (min)
Time Interval........................	=	5.00 (min)

HYDROGRAPH # 2 TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE20

Peak Discharge.......................	=	29.59 (cfs)
Time to Peak.........................	=	490.00 (min)
Time Interval........................	=	10.00 (min)

HYDROGRAPH # 3 TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE30

Peak Discharge.......................	=	28.23 (cfs)
Time to Peak.........................	=	480.00 (min)
Time Interval........................	=	5.00 (min)

HYDROGRAPH # 4 TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE40

Peak Discharge.......................	=	36.48 (cfs)
Time to Peak.........................	=	485.00 (min)
Time Interval........................	=	5.00 (min)

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HYDROGRAPH REPORT

RECORD NUMBER : 10
TYPE : COMBINE
DESCRIPTION : 10+20+30+40+50+60

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	234.94	(cfs)
Volume....................................	=	101.37	(acft)
Time Interval.............................	=	5.00	(min)
Time to Peak..............................	=	485.00	(min)
Time of Base..............................	=	1795.00	(min)

[COMBINE HYDROGRAPH RECORD #]

HYDROGRAPH # 1 TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE10

Peak Discharge........................	=	31.74	(cfs)
Time to Peak..........................	=	480.00	(min)
Time Interval.........................	=	5.00	(min)

HYDROGRAPH # 2 TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE20

Peak Discharge........................	=	29.59	(cfs)
Time to Peak..........................	=	490.00	(min)
Time Interval.........................	=	10.00	(min)

HYDROGRAPH # 3 TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE30

Peak Discharge........................	=	28.23	(cfs)
Time to Peak..........................	=	480.00	(min)
Time Interval.........................	=	5.00	(min)

HYDROGRAPH # 4 TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE40

Peak Discharge........................	=	36.48	(cfs)
Time to Peak..........................	=	485.00	(min)
Time Interval.........................	=	5.00	(min)

HYDROGRAPH # 5 TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE50

Peak Discharge........................	=	57.16	(cfs)
Time to Peak..........................	=	485.00	(min)
Time Interval.........................	=	5.00	(min)

HYDROGRAPH # 6 TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE60

Peak Discharge.........................	=	54.61 (cfs)
Time to Peak...........................	=	480.00 (min)
Time Interval..........................	=	5.00 (min)

HYDROGRAPH REPORT

RECORD NUMBER : 11
TYPE : RESER MOD. PULS
DESCRIPTION : Pond 1 Outflow

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	171.55 (cfs)
Volume....................................	=	101.37 (acft)
Time Interval.............................	=	5.00 (min)
Time to Peak..............................	=	510.00 (min)
Time of Base..............................	=	5430.00 (min)
Peak Elevation............................	=	0.00 (ft)

[RESERVOIR STRUCTURE INFORMATION]

Reservoir #...............................	=	1
Description...............................	=	Pond 1
Storage type..............................	=	TRAP BASIN
Max storage...............................	=	509750.00 Cuft
Discharge type............................	=	COMP STAGE/DIS
Max discharge.............................	=	173.52 cfs

[RESERVOIR INFORMATION]

Reservoir #...............................	=	1
Reservoir Description.....................	=	Pond 1

[INFLOW HYDROGRAPH INFORMATION]

Hydrograph #..............................	=	10
Hydrograph Description....................	=	10+20+30+40+50+60

HYDROGRAPH REPORT

RECORD NUMBER : 12
TYPE : COMBINE
DESCRIPTION : Pond 2 Inflow

[HYDROGRAPH INFORMATION]

Peak Discharge	=	252.67 (cfs)
Volume	=	144.67 (acft)
Time Interval	=	5.00 (min)
Time to Peak	=	500.00 (min)
Time of Base	=	5430.00 (min)

[COMBINE HYDROGRAPH RECORD #]

HYDROGRAPH # 11 TYPE : RESER MOD. PULS
DESCRIPTION : Pond 1 Outflow

Peak Discharge	=	171.55 (cfs)
Time to Peak	=	510.00 (min)
Time Interval	=	5.00 (min)

HYDROGRAPH # 7 TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE70

Peak Discharge	=	25.73 (cfs)
Time to Peak	=	485.00 (min)
Time Interval	=	5.00 (min)

HYDROGRAPH # 8 TYPE : SANTA BARBARA
DESCRIPTION : ULTIMATE-25-SE80

Peak Discharge	=	75.71 (cfs)
Time to Peak	=	485.00 (min)
Time Interval	=	5.00 (min)

HYDROGRAPH REPORT

RECORD NUMBER : 13
TYPE : RESER MOD. PULS
DESCRIPTION : Pond 2 Outflow

[HYDROGRAPH INFORMATION]

Peak Discharge............................	=	189.64 (cfs)
Volume....................................	=	144.67 (acft)
Time Interval.............................	=	5.00 (min)
Time to Peak..............................	=	555.00 (min)
Time of Base..............................	=	5480.00 (min)
Peak Elevation............................	=	0.00 (ft)

[RESERVOIR STRUCTURE INFORMATION]

Reservoir #...............................	=	2
Description...............................	=	Pond 2
Storage type..............................	=	TRAP BASIN
Max storage...............................	=	739200.00 Cuft
Discharge type............................	=	COMP STAGE/DIS
Max discharge.............................	=	191.98 cfs

[RESERVOIR INFORMATION]

Reservoir #...............................	=	2
Reservoir Description.....................	=	Pond 2

[INFLOW HYDROGRAPH INFORMATION]

Hydrograph #..............................	=	12
Hydrograph Description....................	=	Pond 2 Inflow

RESERVOIR REPORT

RECORD NUMBER : 1
STORAGE TYPE : TRAP BASIN
DISCHARGE TYPE : COMP STAGE/DIS
DESCRIPTION : Pond 1

[RATING CURVE LIMIT]

Minimum Elevation.........................	=	407.00	(ft)
Maximum Elevation.........................	=	412.00	(ft)
Elevation Increment.......................	=	0.25	(ft)

[STAGE STORAGE INFORMATION]

RESERVOIR DESCRIPTION:

Base length...............................	=	800.00	(ft)
Base width................................	=	110.00	(ft)
Top length................................	=	830.00	(ft)
Top width.................................	=	140.00	(ft)

[STAGE DISCHARGE INFORMATION]

OUTLET STRUCTURE:

STR # : 1
TYPE : CIRCULAR ORIFICE
DESCRIPTION : Pond 1 Underflow

STR # : 2
TYPE : RECTANGULAR WEIR CONTRACTED
DESCRIPTION : Pond 1 Overflow

RESERVOIR REPORT

RECORD NUMBER : 2
STORAGE TYPE : TRAP BASIN
DISCHARGE TYPE : COMP STAGE/DIS
DESCRIPTION : Pond 2

[RATING CURVE LIMIT]

Minimum Elevation	=	396.00	(ft)
Maximum Elevation	=	402.00	(ft)
Elevation Increment	=	0.25	(ft)

[STAGE STORAGE INFORMATION]

RESERVOIR DESCRIPTION:

Base length	=	970.00	(ft)
Base width	=	110.00	(ft)
Top length	=	1000.00	(ft)
Top width	=	140.00	(ft)

[STAGE DISCHARGE INFORMATION]

OUTLET STRUCTURE:

STR # : 5
TYPE : RECTANGULAR ORIFICE
DESCRIPTION : Pond 2 Underflow2

STR # : 4
TYPE : RECTANGULAR WEIR CONTRACTED
DESCRIPTION : Pond 2 Overflow

OUTLET STRUCTURE REPORT

RECORD NUMBER : 1
TYPE : CIRCULAR ORIFICE
DESCRIPTION : Pond 1 Underflow

[RATING CURVE LIMIT]

Minimum Elevation.........................	=	407.00 (ft)
Maximum Elevation.........................	=	412.00 (ft)
Elevation Increment.......................	=	0.25 (ft)

[OUTLET STRUCTURE INFORMATION]

Radius................................. ..	=	1.75 (ft)
Coefficient Co............................	=	0.80000
Invert Elevation..........................	=	407.00 (ft)
# of Openings.............................	=	1

[CIRCULAR ORIFICE EQUATION]

Q = Co*A*[2gh]/k]^0.5
A = Wetted area, (sqft)
K = 1

OUTLET STRUCTURE REPORT

RECORD NUMBER : 2
TYPE : RECTANGULAR WEIR CONTRACTED
DESCRIPTION : Pond 1 Overflow

[RATING CURVE LIMIT]

Minimum Elevation.........................	=	407.00 (ft)
Maximum Elevation.........................	=	412.00 (ft)
Elevation Increment.......................	=	0.25 (ft)

[OUTLET STRUCTURE INFORMATION]

Crest Length..............................	=	7.00 (ft)
Crest Elevation...........................	=	410.00 (ft)
Coefficient Cw............................	=	3.33000
Exponential...............................	=	1.50000

[RECTANGULAR CONTRACTED EQUATION]

Q = Cw(L-0.2H)H^exp
H = Headwater depth above inlet control section invert, (ft)
L = Crest length, (ft)

OUTLET STRUCTURE REPORT

RECORD NUMBER : 4
TYPE : RECTANGULAR WEIR CONTRACTED
DESCRIPTION : Pond 2 Overflow

[RATING CURVE LIMIT]

Minimum Elevation.........................	=	396.00 (ft)
Maximum Elevation.........................	=	402.00 (ft)
Elevation Increment.......................	=	0.25 (ft)

[OUTLET STRUCTURE INFORMATION]

Crest Length..............................	=	5.00 (ft)
Crest Elevation...........................	=	399.00 (ft)
Coefficient Cw............................	=	3.33000
Exponential...............................	=	1.50000

[RECTANGULAR CONTRACTED EQUATION]

Q = Cw(L-0.2H)H^exp
H = Headwater depth above inlet control section invert, (ft)
L = Crest length, (ft)

OUTLET STRUCTURE REPORT

RECORD NUMBER : 5
TYPE : RECTANGULAR ORIFICE
DESCRIPTION : Pond 2 Underflow2

[RATING CURVE LIMIT]

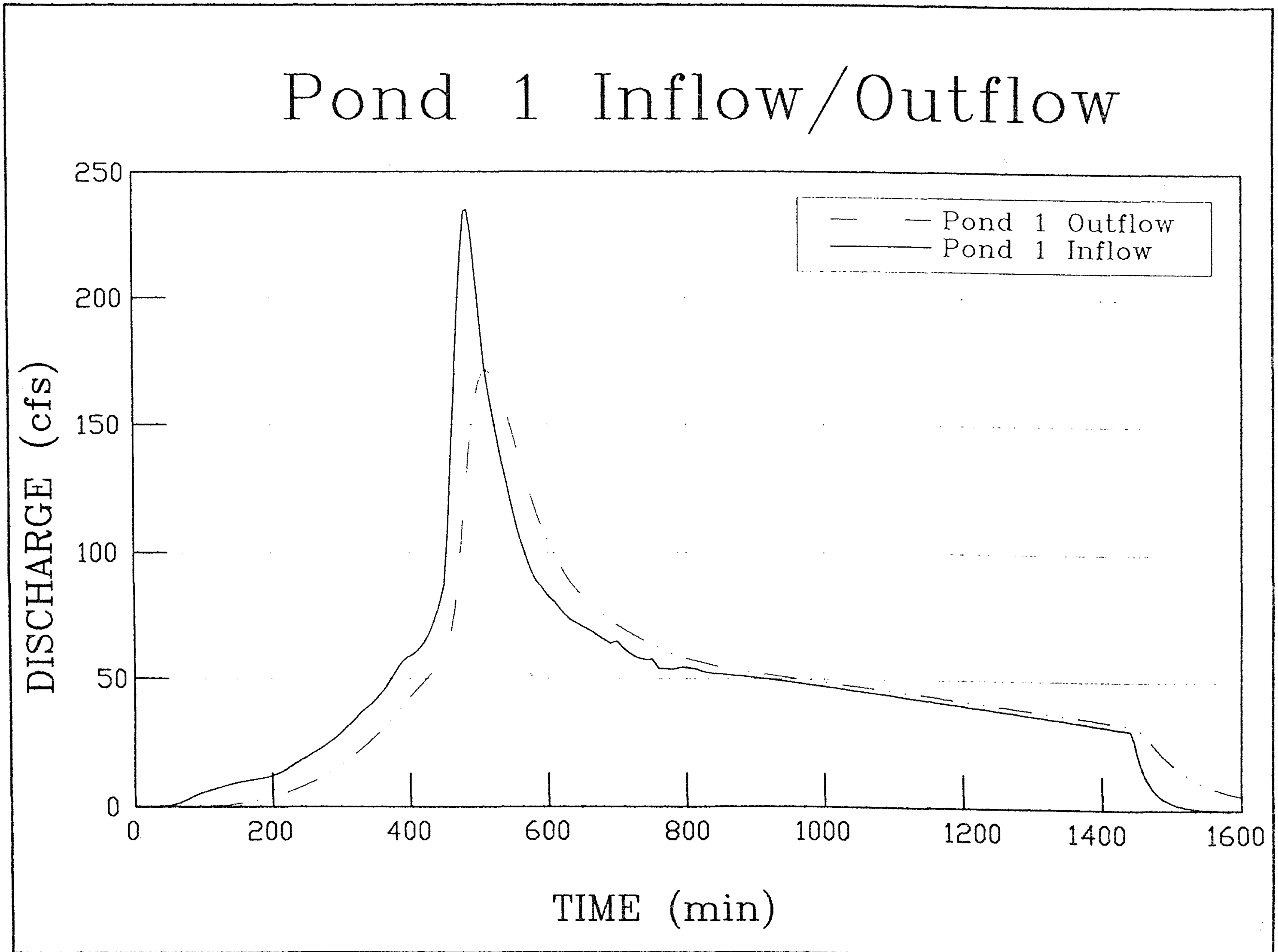
Minimum Elevation.........................	=	396.00 (ft)
Maximum Elevation.........................	=	402.00 (ft)
Elevation Increment.......................	=	0.25 (ft)

[OUTLET STRUCTURE INFORMATION]

Width....................................	=	7.00 (ft)
Height...................................	=	1.50 (ft)
Coefficient Co...........................	=	0.60000
Invert Elevation.........................	=	396.00 (ft)
# of Openings............................	=	1

[RECTANGULAR ORIFICE EQUATION]

Q = Co*A*[2gh]/k]^0.5
A = Wetted area, (sqft)
K = 1


Pond 1 Inflow/Outflow
Pond 1 Outflow
Pond 1 Inflow
DISCHARGE (cfs)
TIME (min)
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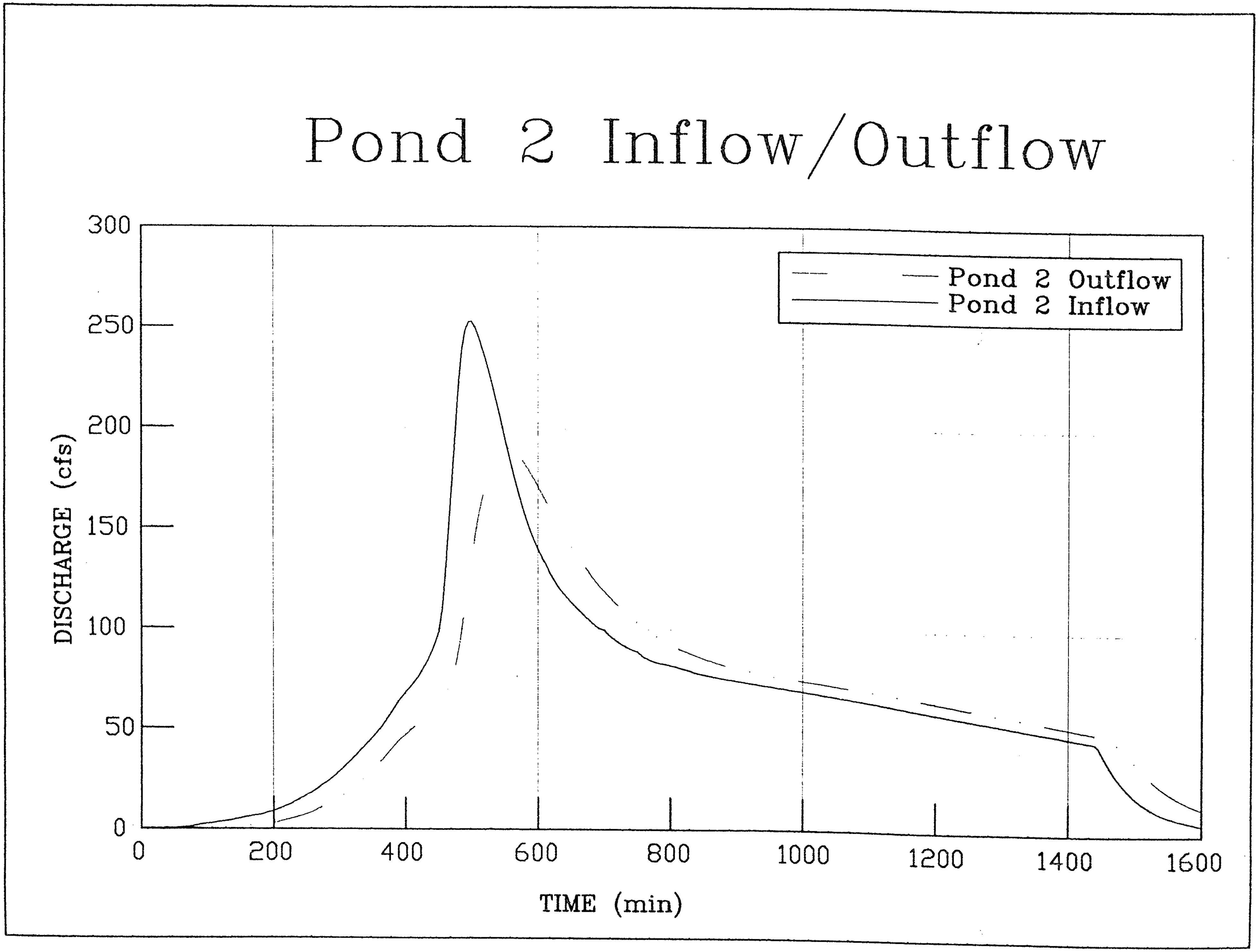
50
100
150
200
250
0
200
400
600
800
1000
1200
1400
1600


Pond 2 Inflow/Outflow
DISCHARGE (cfs)
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50
100
150
200
250
300
TIME (min)
0
200
400
600
800
1000
1200
1400
1600
Pond 2 Outflow
Pond 2 Inflow

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: South End Basin

Comment: 48" Pipe, Forest Ridge Road to S. End Court

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0075 ft/ft
Manning's n.......	0.013
Discharge.........	124.00 cfs

Computed Results:

Full Flow Diameter.....	4.00 ft
Full Flow Depth........	4.00 ft
Velocity..........	9.89 fps
Flow Area.........	12.54 sf
Critical Depth....	3.35 ft
Critical Slope....	0.0072 ft/ft
Percent Full......	100.00 %
Full Capacity.....	124.00 cfs
QMAX @.94D........	133.39 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: South End Basin

Comment: 48" Pipe, South End Road to South

Solve For Full Flow Diameter

```
Given Input Data:
          Slope..............    0.0080 ft/ft
          Manning's n........    0.013
          Discharge..........  126.00 cfs

Computed Results:
     Full Flow Diameter.....     3.97 ft
     Full Flow Depth........     3.97 ft
          Velocity..........    10.17 fps
          Flow Area.........    12.38 sf
          Critical Depth....     3.37 ft
          Critical Slope....     0.0076 ft/ft
          Percent Full......   100.00 %
          Full Capacity.....   126.00 cfs
          QMAX @.94D........   135.54 cfs
          Froude Number.....    FULL
```

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: South End Basin

Comment: 30" Pipe, Crossing W. of Forest Ridge Rd.

Solve For Full Flow Diameter

Given Input Data:

Slope..............	0.0200 ft/ft
Manning's n........	0.013
Discharge..........	57.20 cfs

Computed Results:

Full Flow Diameter.....	2.49 ft
Full Flow Depth........	2.49 ft
Velocity...........	11.78 fps
Flow Area..........	4.86 sf
Critical Depth....	2.37 ft
Critical Slope....	0.0173 ft/ft
Percent Full......	100.00 %
Full Capacity.....	57.20 cfs
QMAX @.94D........	61.53 cfs
Froude Number.....	FULL

APPENDIX D

COST ESTIMATES WORKSHEETS

The following cost estimates are based on 1995 dollars, and reflect typical costs for projects of similar size and scope. No appraisals were done, nor were any property owners contacted regarding costs. Although these estimates are based on costs for completed projects, land and construction costs vary widely, so the estimated costs must be considered to be approximate only.

OREGON CITY DRAINAGE MASTER PLAN

PRELIMINARY ENGINEER'S OPINION OF CONSTRUCTION COSTS

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
SOUTH END BASIN					
	Phase 1 - South End Road Improvements				
1	Phase 1 Easement	4,000	SF	$ 0.50	$ 2,000.00
	Acquisition Fees	1	Parcel	$ 1,000.00	$ 1,000.00
	Total Phase 1 Esmt Cost				$ **3,000.00**
2	12" Dia. Storm Drain Pipe	100	LF	$ 24.00	$ 2,400.00
3	15" Dia. Storm Drain Pipe	50	LF	$ 27.00	$ 1,350.00
4	18" Dia. Storm Drain Pipe	100	LF	$ 38.00	$ 3,800.00
5	24" Dia. Storm Drain Pipe	0	LF	$ 44.00	$ 0.00
6	30" Dia. Storm Drain Pipe	400	LF	$ 60.00	$ 24,000.00
7	42" Dia. Storm Drain Pipe	500	LF	$ 90.00	$ 45,000.00
8	48" Dia. Storm Drain Pipe	200	LF	$ 96.00	$ 19,200.00
9	60" Manhole	1	EA	$ 2,200.00	$ 2,200.00
10	84" Manhole	3	EA	$ 4,000.00	$ 12,000.00
11	Connect to Exist. Storm Line	1	EA	$ 500.00	$ 500.00
12	Catch Basin (Std.)	2	EA	$ 650.00	$ 1,300.00
13	Catch Bsin (O.S.)	2	EA	$ 800.00	$ 1,600.00
14	Field Inlet	2	EA	$ 600.00	$ 1,200.00
15	Outfall Structure	2	EA	$ 2,500.00	$ 5,000.00
16	A.C. Sawcut	240	LF	$ 1.50	$ 360.00
17	A.C. Repair	40	SY	$ 15.75	$ 630.00
	Total Phase 1				**$ 123,540.00**
	Phase 2 - Three Detention Ponds				
1	Phase 2 Easement	400,000	SF	$ 0.50	$ 200,000.00
	Acquisition Fees	8	Parcel	$ 1,000.00	$ 8,000.00
	Total Phase 2 Esmt Cost				$ **208,000.00**
2	Detention Pond	2	EA	$ 50,000.00	$ 100,000.00
3	Exist. Pond Dam Reconstruction	1	LS	$ 65,000.00	$ 65,000.00
	Total Phase 2				**$ 373,000.00**

OREGON CITY DRAINAGE MASTER PLAN

PRELIMINARY ENGINEER'S OPINION OF CONSTRUCTION COSTS

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT		UNIT COST		TOTAL COST
	Phase 3 - Oak Tree Subdivision Improvements						
1	Phase 3 Easement	4,000	SF	$	0.50	$	2,000.00
	Acquisition Fees	2	Parcel	$	1,000.00	$	2,000.00
	Total Phase 3 Esmt Cost					$	**4,000.00**
2	12" Dia. Storm Drain Pipe	950	LF	$	24.00	$	22,800.00
3	Connect to Exist. Storm Line	3	EA	$	500.00	$	1,500.00
4	Catch Basin (Std.)	3	EA	$	650.00	$	1,950.00
5	48" Manhole	1	EA	$	1,400.00	$	1,400.00
6	Existing Pond Reconstruction	1	LS	$	30,000.00	$	30,000.00
7	A.C. Sawcut	1,400	LF	$	1.50	$	2,100.00
8	A.C. Repair	700	SY	$	15.75	$	11,025.00
	Total Phase 3					$	**74,775.00**
	Phase 4 - Easement Acquisions						
1	Phase 4 Easement	180,000	SF	$	0.50	$	90,000.00
	Acquisition Fees	25	Parcel	$	1,000.00	$	25,000.00
	Total Phase 4 Esmt Cost					$	**115,000.00**
	Total Phase 4					$	**115,000.00**

TOTAL CONSTRUCTION COST:	$	**686,315.00**
Additional Const. Costs (Traffic Control, Mobilization, Clearing, Contingency)(20%)	$	**137,263.00**
Engineering Design and Contract Administration (15%)	$	**102,947.25**
TOTAL PROJECT COST:	$	**926,525.25**

KAMPE ASSOCIATES, INC.

Planning/Civil Engineering/Land Surveying

NOTE Estimate does not include relocation of existing utilities or road reconstruction not listed.