Chapter 2

Design Charts

Introduction

Overview

The hydrologic methods, Nolte, Sacramento, and Sato, are to be used for the design of drainage facilities and water quality detention facilities in the City and County of Sacramento. Design charts are provided to aid the calculation of runoff for drainage facilities with less than 640 acres (260 hectares) of contributing area. There are charts of peak flow for storm drain and street drainage design using both the Nolte and Sacramento methods. (Peak flows for basins where storage is a consideration, such as detention basins, should be determined using SACPRE, not the design charts.) A design chart has also been created for determining the quantity of storage required for water quality detention basins using the Sato method. Design charts in English units are located at the end of this chapter, with charts in SI units immediately following. The design charts available and their appropriate application are summarized in Table 2-1.

Applications in the County

The County allows the use of Nolte charts for storm drain and street drainage design, but may require the use of the Sacramento method in special design cases. Design flows given in the Nolte charts generally represent from 2- to 5-year recurrence interval flood peaks. Figure 2-1 shows the design criteria for storm drains in the County.

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Introduction (continued)

Applications in the City

The City historically has used constant unit flow rates for design purposes. These rates are 0.20 cubic feet per second for residential land use, and 0.30 cubic feet per second for commercial, industrial, and multiple family land uses. These rates will continue to be used for drainage facility design for infill areas, but only if they control the design as indicated in Figure 2-2. If it is a special case design, the City may require the use of the Sacramento method for pipe design. Even when the constant unit flow rates are used for pipe design, the Sacramento method may be required to determine the depth of flooding in the 10-year and 100-year design storm events.
The Sacramento method will be used in the City for all new drainage systems with gravity outfalls not restricted by the capacities of existing systems as shown in Figure 2-3.

The City reserves the right to make a determination of design runoff on a case by case basis, and may require other methods at their discretion.

Special Design Cases

The City and County may, at their discretion, require the use of the Sacramento method for design of drainage facilities in the following special cases:

- streets designated for emergency evacuation
- high use public areas
- areas with potential loss of life
- areas with potential high property damages
- areas with no overland release
- areas lower than surrounding elevations (sumps)

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Summary of Design Charts

Table 2-1. Summary of Design Charts and Applications

Application		Agency	Method	Basin Size	Hydrologic Calculation	Zone	Land Use	Figure #
Design of · Street drainage · Storm drains · Culverts not associated with channels	Standard	County	Nolte	< 50 ac < 20 ha	Design Flow	All	Commercial Residential	2-5
				50-160 ac 20-65 ha		All	Residential	2-6
				50-160 ac 20-65 ha		All	Commercial	2-7
				160-640 ac 65-260 ha		Hydrologic 1	20,50,80% Impervious	2-8
				160-640 ac 65-260 ha		Hydrologic2	20,50,80% Impervious	2-9
				160-640 ac 65-260 ha		Hydrologic3	20,50,80% Impervious	2-10
	Infill	City	0.20 cfs/ac	<640 ac <260 ha		Hydrologic2 ,3	Residential	
			0.30 cfs/ac	<640 ac <260 ha		Hydrologic2 ,3	Commercial Industrial Multi-Family	
Design of: · Street drainage · Storm drains · Culverts associated with channels	Special Case	County	Sacramento	0-80 ac 0-30 ha	10-yr flow	Rainfall 1 2 3	1, 20, 50, 80, 95% Impervious	2-12 2-14 2-16
	Standard	City			100-yr flow	Rainfall 1 2 3	1, 20, 50, 80, 95% Impervious	2-18 2-20 2-22
				80-640 ac 30-260 ha	10-yr flow	Rainfall 1 2 3	1, 20, 50, 80, 95% Impervious	2-13 2-15 2-17
					100-yr flow	Rainfall 1 2 3	1, 20, 50, 80, 95% Impervious	2-19 2-21 2-23
				0-640 ac 0-260 ha	flow (vs lag time)	All	All	2-24
Water quality detention basins	Standard	City and County	Sato	0-640 ac 0-260 ha	volume	All	All	2-25

Nolte Charts

Use

The Nolte design charts are intended for use in Sacramento County, but may be used in the City at their discretion.

Background

The Nolte charts have been used for pipe design in Sacramento County since the early 1960's. The Nolte charts were developed by assuming hydrologic features of drainage basins up to 160 acres and calculating runoff using the widely accepted Rational method. Nolte charts for areas between 160 acres and 2 square miles were developed by transitioning to values based on Nolte regional equations for areas greater than 2 square miles. The County has found the Nolte charts to be adequate for drainage design in most cases. While some nuisance flooding may occur in localized areas, there does not appear to be sufficient historic flood frequency damage information to warrant changing the standard Nolte method for pipe design. The City prefers to base most of its remaining development on the Sacramento method, where practical.

Hydrologic Zones

The Nolte charts divide Sacramento County into three hydrologic zones which are used in the estimation of design flows. These zones were delineated on the basis of predominant surface soils, topography and general surface runoff potential. The hydrologic zones are shown in Figure 2-4 and are described as follows:

Zone	Description	Slopes %	Runoff Potential
1 & 2	Foothills	8-12	Medium to Very Rapid
3	Valley	0-8	Very Slow to Medium

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Nolte Charts (continued)

Design Frequency

The Nolte method design charts vary the precipitation recurrence interval with the size of the drainage basin as described below.

Basin Size acres	Basin Size hectares	Recurrence Interval years
< 30	< 12	2
30-100	12-40	2-5
> 100	> 40	5-10

Areas <160 Acres (65 Hectares)

Three Nolte charts, Figures 2-5 to 2-7, are available to determine design runoff for areas less than 160 acres (65 hectares). These charts break land use into three general categories; residential, commercial, and multi-family. The charts provide design runoff for residential and commercial land uses. Design runoff for multi-family land use is determined with a formula which combines the residential and commercial values. The appropriate Nolte curve given the basin percent impervious or the Sacramento County land use is summarized below.

Nolte Land use	Percent Impervious	Sacramento County Land Use Description
Residential	10-50	Agricultural/Residential Low density residential (<5 DU/Acre) Schools
Multi-Family	50-70	Low density residential (>5 DU/Acre) Medium density residential High density residential (<40 DU/Acre) Extensive Industrial
Commercial	70-90	High Density Residential (>40 DU/Acre) Intensive industrial Commercial/Offices Core area commercial

Nolte Charts (continued)

Areas <160 Acres (65 Hectares) (Cont.)

Multi-Family Formula

The following formula is used to determine the design runoff for multi-family land use:

$$Q_m = Q_r + (Q_c - Q_r) * \frac{(I - 50)}{40}$$

where:
- Q_m = Flow for multiple family area
- Q_c = Flow from commercial curve for total area of watershed
- Q_r = Flow from residential curve for total area of watershed
- I = Percent impervious

Multiple Zoning Formula

In drainage areas which contain multiple zoning the runoff should be computed with the following formula.

$$Q_{design} = Q_r + (Q_m - Q_r) * \frac{A_m}{A_t} * (Q_c - Q_r) * \frac{A_c}{A_t}$$

where:
- Q_r = Flow from residential curve for total area of watershed
- Q_m = Flow from multiple family formula
- Q_c = Flow from commercial curve for total area of watershed
- A_m = Multiple family area
- A_c = Commercial area
- A_t = Total area

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Nolte Charts (continued)

Areas >160 Acres (65 Hectares) (Cont.)

There are three Nolte charts, Figures 2-8 to 2-10, to determine design runoff for areas between 160 and 640 acres, (65 and 260 Hectares). The charts provide design runoff for low, medium and high density land use. The appropriate Nolte curve for a given basin percent impervious or Sacramento County land use is summarized below.

Nolte Land Use	Percent Impervious	Sacramento County Land Use Description
Low density	20	Agricultural/Residential
Medium density	50	Low density residential Schools Medium density residential High density residential (<40 DU/Acre) Extensive Industrial
High density	80	High Density Residential (>40 DU/Acre) Commercial/Offices Core area commercial Intensive industrial

Sacramento Charts

Use

The Sacramento design charts are intended for use in both the City and County of Sacramento.

Rainfall Zones

The Sacramento method divides the City and County of Sacramento into three rainfall zones based on a statistical analysis of precipitation gages. (This is described in detail in chapter 4.) The rainfall zones are shown in Figure 2-11, and on a large foldout map at the end of this Volume. **The rainfall zones are different than the hydrologic zones used in the Nolte method and shown in Figure 2-3.**

Design Frequency

The Sacramento method charts are based on discrete recurrence intervals. Peak flow is given versus drainage area for the 10- and 100-year recurrence intervals. Peak flow is also given versus lag time for the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence intervals.

Peak Flow Areas < 80 Acres (30 Hectares) Based on Area

Six Sacramento method charts are available to determine design runoff for areas less than 80 acres (30 hectares). Figures 2-12, 2-14 and 2-16 give the 10-year peak flow, and Figures 2-18, 2-20 and 2-22 give the 100-year peak flow. These charts were developed by assuming typical hydrologic and hydraulic characteristics for basins of varying sizes and calculating the resulting peak flows using the Sacramento method. The assumptions are given in the accompanying disk.

Peak Flow Areas from 80 to 640 Acres (30 to 260 Hectares) Based on Area

Six Sacramento method charts are available to determine design runoff for areas between 80 acres (30 hectares) and 640 acres (260 hectares). Figures 2-13, 2-15 and 2-17 give the 10-year peak flow, and Figures 2-19, 2-21 and 2-23 give the 100-year peak flow.

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Sacramento Charts (continued)

Peak Flow for Areas < 640 Acres (260 Hectares) Based on Basin Lag

Figure 2-24 gives design flow based on basin lag time according to the Sacramento method. The chart was created by assuming typical land use and hydrologic soil types in the Sacramento County and calculating peak flows according to the Sacramento method. (See accompanying disk for assumptions.) The chart provides design flow estimates in cfs/acre (m^3/s/hectare) as a function of lag time for recurrence intervals from 2 to 500 years. Use of this chart is limited to basins less than 640 acres (260 hectares). For more information on basin lag refer to Chapter 7. The computer program SACPRE aids in the calculation of lag time.

Percent impervious and rainfall zones are not required for Figure 2-24 since peak flow is given versus lag time.

Land Use Versus Percent Impervious

The average percent impervious for a given drainage area should be determined based on a composite land use. The design flow can then be interpolated from Figures 2-12 through 2-23. For a detailed description of determining percent impervious refer to Chapter 5, Table 5-3 lists the percent impervious for various types of land use in the City and County of Sacramento. The computer program SACPRE aids the user in this calculation.

Sato Chart

Use

The Sato design chart is intended for use in both the City and County of Sacramento.

Introduction

Urban stormwater management has been expanded to address water quality issues in addition to the traditional water quantity issues. One of the most common best management practices recommended for water quality enhancement is the dry-extended detention basin. To aid in the design of water quality detention basins a design chart, Figure 2-25, was developed by J.F. Sato and Associates for Sacramento County. The chart gives the optimum volume of storage for water quality detention given the drainage area percent impervious.

Design Criteria

The design of stormwater facilities is often based on a precipitation event frequency such as a 100 year storm. This practice provides some assurance that the facility will operate effectively for the given design frequency. In the design of water quality detention basins it is not as cost effective to design to a particular design frequency.

The effectiveness of a water quality detention basin is based on the total volume of pollutants removed, which is dependent on the total volume of runoff captured. The majority of the total annual runoff volume is generated by the smaller more frequent storms (less than a 2 year recurrence). The Sato method concentrates on sizing water quality detention basins to capture the greatest storm water volume overall rather than capturing a particular design storm. This results in water quality detention basins which are effective but not oversized.

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Sato Chart (continued)

Methodology

The method used by J.F. Sato and Associates to develop the chart for sizing water quality detention basins is summarized in the steps below. A detailed report on the methodology used is included in the Appendix.

1. Historical precipitation records from 1963 to 1990 were analyzed and individual precipitation events were identified.
2. Runoff volumes from each event were determined using a rainfall/runoff coefficient.
3. A range of detention basin volumes were evaluated to determine the percent of the total historical runoff volume each basin would capture.
4. Increases in basin volume were compared to increases in the total volume of runoff captured by the basin.
5. The point at which increasing the basin size produced diminishing returns with respect to increased runoff captured was determined to be the optimal basin size.
6. A design chart was developed by plotting basin percent impervious versus required storage.

Application

The Sato design chart in Figure 2-25 gives the volume of a water quality detention basin or the water quality portion of a dual purpose basin based on the size and the percent impervious of the contributing drainage. Use of the Sato design chart should be limited to drainage areas less than 640 acres (259 hectares).

The water quality storage volume obtained from Figure 2-25 should be used as a starting point for the basin design. The detention basin outlet should normally be designed to release 75 percent of the design volume in a minimum of 24 hours and the total design volume over a period of 40 to 48 hours. Additional discussion of water quality detention basins is included in Volumes 3, 4, and 5 of the City/County Drainage Manual.

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Sato Chart (continued)

Sato Chart Example

The following example demonstrates the use of the Sato design chart in Figure 2-25.

Given: Watershed area = 250 acres (101 hectares)
Percent impervious = 75

Determine: The required storage volume for a water quality detention basin.

1. Determine required storage in runoff depth from Figure 2-25
   0.79 in (20 mm)

2. Calculate the storage volume in ac-ft and ha-m
   0.79 in x 250 ac x 12 in/ft = 16.5 ac-ft
   20 mm x 101 ha x 1 m/1000 mm = 2.02 ha-m