SECTION 4
STORM DRAINAGE

4.01 GENERAL

These standards shall provide minimum requirements for the design of Storm Drainage and related appurtenances within the City of West Sacramento rights of way and easements. The design criteria of proposed improvements not included in these standards shall be subject to the approval of the City Engineer.

4.02 HYDROLOGY

A. General

1. The methods and storm recurrence intervals indicated below shall be used in determination of runoff quantities, assuming ultimate development of the upstream watershed.

2. Hydrologic calculations shall be submitted to the City Engineer along with watershed maps, which indicate area distributions within the watershed and other information pertinent to the determination of storm runoff.

3. Drainage facilities to be located within the Southport Area shall be designed in accordance with the Southport Drainage Master Plan.

4. These standards assume two categories of drainage facilities:

   a. ***Type 1 Drainage Facilities*** include the following:
      - Channels
      - Culverts associated with channels
      - Bridges
      - Detention ponds
      - Drainage pump stations

   b. ***Type 2 Drainage Facilities*** include the following:
      - Roadside ditches
      - Culverts associated with roadside ditches
      - Pipe systems
      - Overland conveyance systems

B. Design Criteria

5. The "Sacramento Method"

   a. The *Sacramento Method* shall be used assuming a 100-year storm event in the design of *Type 1 Drainage Facilities and overland conveyance systems*. At the discretion of the City Engineer, these facilities shall also be evaluated assuming a 10-year storm event.

   b. The *Sacramento Method* may be applied through the use of design charts included in these Standards or through the use of the

SACPRE and HEC-1 computer programs at the design engineers discretion. A copy of the SACPRE program is available from the City of West Sacramento Community Development Department.

c. Computational Procedure Utilizing Design Charts

1. Delineate the subbasin contributing drainage to the point or node of interest.

2. Identify the area, by land use, within the subbasin.

3. Determine the percent impervious for the various land uses within the subbasin in accordance with Table 4-1.

4. Calculate an area-weighted effective percent impervious for the subbasin.

5. Calculate the *Sacramento Method* peak design flow using the equations below or read the *Sacramento Method* peak design flow from Figure 4-1 through Figure 4-4.

$$Q_{Design} = KA^n$$

Where:

Q_{Design} = peak flow (cfs)

A~~e~~ = cumulative drainage area (acres)

K = coefficient (see equations below)

n = coefficient (see equations below)

PI = percent impervious

$$K_{10\text{-}year} = 1.0647 + 0.018920 * PI - 8.453 \times 10^{-5} * PI^2$$

$$K_{100\text{-}year} = 1.7637 + 0.020999 * PI - 4.562 \times 10^{-5} * PI^2$$

$$n_{10\text{-}year} = 0.7531 + 0.001509 * PI - 0.863 \times 10^{-5} * PI^2$$

$$n_{100\text{-}year} = 0.7531 + 0.001278 * PI - 0.902 \times 10^{-5} * PI^2$$

d. Computational Procedure Utilizing SACPRE and HEC-1

1. Delineate the subbasin contributing drainage to the point or node of interest.

2. Identify the area, by land use, within the subbasin.

3. Determine the percent impervious for the various land uses within the subbasin in accordance with Table 4-1.
4. Calculate an area-weighted effective percent impervious for the subbasin.
5. Determine the Basin "n" for the various land uses within the subbasin in accordance with Table 4-4. *(Unit Hydrographs and Precipitation are generated using SACPRE, which employs the U.S. Bureau of Reclamation's Urban Unit Hydrograph Method. SACPRE does not include land use designations that correspond with the City of West Sacramento land use designations. Sub-basin lag times can be calculated outside the SACPRE program using the Basin "n" Method and input directly into SACPRE.)*
6. Calculate an area-weighted Basin "n" for the subbasin.
7. Determine the hydrologic soils groups and associated uniform infiltration rates for the various land uses within the subbasin in accordance with Table 4-3.
8. Calculate an area-weighted uniform infiltration rate for the subbasin.
9. Determine the initial loss based upon the storm recurrence in accordance with Table 4-2.
10. Determine the lag multiplication factor for overland release based upon the storm recurrence in accordance with Table 4-5.
11. Determine the subbasin lag time based upon the following equation:

$$L_g = 1560nf(LL_c/S^{0.5})^{0.33}$$

Where:

L_g = Lag time (minutes)

L = Length of longest watercourse, measured as approximately 90% of the distance from the point of interest to the headwater divide of the basin (miles).

L_c = Length along the longest watercourse measured upstream from the point of interest to a point close to the centroid of the basin (miles)

S = Slope of 90% of the longest watercourse between the headwaters and concentration point, (ft/mi).

n = Basin "n" from Table 4-4

f = Lag frequency factor from Table 4-5, to

account for flows exceeding pipe capacities
causing temporary flooding in streets and
thereby increasing lag times.

1. Use the HEC-1 preprocessor computer program, SACPRE to develop an input file for HEC-1. Running the HEC-1 computer program will produce a runoff hydrograph. The *Sacramento Method* hydrologic Zone 2 shall be used.

2. Unsteady State Conditions

   a. Where unsteady state conditions exist, using an unsteady state model such as UNET may be necessary to design *"Type 1 drainage facilities"* in lieu of the *Sacramento Method.* When UNET is used to evaluate flooding, runoff hydrographs used within UNET should be developed using SACPRE and HEC-1, or other methods as approved by the City Engineer.

3. The "*Nolte Method*"

   a. The "*Nolte Method*" shall be used in the design of *Type 2 Drainage Facilities, except for overland conveyance systems.*

   b. The Nolte Design Charts included herein as Figures 4-5 through 4-8 vary the precipitation recurrence interval with the size of the drainage basin. For basins less than 30 acres, the recurrence interval is 2 years. For basins between 30 and 100 acres, the recurrence interval is 2 to 5 years. For basins greater 100 acres, the recurrence interval is 5 to 10 years.

   c. Computational Procedure

      1. Delineate the subbasin contributing drainage to the point or node of interest.

2. Identify the area, by land use, within the subbasin.

3. Determine the Nolte Formula Classification and associated Land Use Parameter, "I", for the various land uses within the subbasin in accordance with Table 4-6.

4. Calculate the *Nolte Method* peak design flow using the following equations:

   - For drainage areas having the Nolte Formula Classification, **R,** the following formula shall be used:

     $$Q_{design} = Q_r$$

   - For drainage areas having the Nolte Formula Classification, **C,** the following formula shall be used:

     $$Q_{design} = Q_c$$

   - For drainage areas having the Nolte Formula Classification, **M,** the following formula shall be used:

$$Q_{design} = Q_m$$

- For drainage areas with land use having mixed Nolte Formula Classification, the following formula shall be used:

$$Q_{design} = Q_r + (Q_m – Q_r)\ A_m/A_t + (Q_c – Q_r)\ A_c/A_t$$

Where:

Q_{design} = Nolte peak design flow (cfs)

Q_r = Flow from residential curve of Figure 4-5 through 4-8, depending upon the size of the watershed, using total cumulative area of watershed. (cfs).

Q_m = $Q_r + (Q_c – Q_r) * (I-50) / 40$ (cfs)

I = Area-weighted average of land use parameter for areas with Nolte Formula Classification, **M.** See Table 4-6.

Q_c = Flow from commercial curve of Figure 4-5 through 4-8, depending upon the size of the watershed, using total cumulative area of watershed. (cfs).

A_m = Cumulative area of land use with the Nolte Classification, **M.**

A_c = Cumulative area of land use with the Nolte Classification, **C.**

A_t = Total cumulative area of subbasin.

TABLE 4-1

EFFECTIVE PERCENT IMPERVIOUS BY LAND USE

Land Use Description	Effective Percent Impervious
Rural Estates	10
Rural Residential	15
Low Density Residential	30
Medium Density Residential	40
High Density Residential	70
High Rise Residential	80
Neighborhood Commercial	90
Community Commercial	90
Highway Service Commercial	90
Water-related Commercial	90
General Commercial	90
Office	90
Business Park	90
Mixed Use	60
Riverfront Mixed Use	60
Mixed Commercial/Industrial	85
Light Industrial	85
Heavy Industrial	85
Water-related Industrial	85
Public/Quasi-public	50
Recreation and Park	5
Open Space	2
Agriculture	2

Source: Sacramento City/County Drainage Manual, Hydrology Standards, Volume II, December 1996.

TABLE 4-2

INITIAL LOSS BY RECURRENCE INTERVAL

Recurrence Interval	Loss, in.
2	0.40
5	0.25
10	0.20
25	0.15
50	0.12
100	0.10
200	0.08
500	0.06

Source: Sacramento City/County Drainage Manual, Hydrology Standards, Volume II, December 1996.

TABLE 4-3

INFILTRATION RATES BY LAND USE AND HYDROLOGIC SOIL GROUP

Land Use Description	Effective Percent Impervious	Infiltration Rate, in/hr		
		Soil Group B	Soil Group C	Soil Group D
Rural Estates	10	0.18	0.10	0.07
Rural Residential	15	0.18	0.10	0.07
Low Density Residential	30	0.18	0.10	0.07
Medium Density Residential	40	0.18	0.10	0.07
High Density Residential	70	0.17	0.09	0.06
High Rise Residential	80	0.16	0.08	0.05
Neighborhood Commercial	90	0.14	0.07	0.04
Community Commercial	90	0.14	0.07	0.04
Highway Service Commercial	90	0.14	0.07	0.04
Water-related Commercial	90	0.14	0.07	0.04
General Commercial	90	0.14	0.07	0.04
Office	90	0.14	0.07	0.04
Business Park	90	0.14	0.07	0.04
Mixed Use	60	0.18	0.10	0.07
Riverfront Mixed Use	60	0.14	0.07	0.04
Mixed Commercial/Industrial	85	0.17	0.09	0.06
Light Industrial	85	0.17	0.09	0.06
Heavy Industrial	85	0.17	0.09	0.06
Water-related Industrial	85	0.17	0.09	0.06
Public/Quasi-public	50	0.19	0.11	0.75
Recreation and Park	5	0.16	0.09	0.07
Open Space	2	0.18	0.10	0.07
Agriculture	2	0.18	0.10	0.07

Sources: 1. Draft Sacramento City/County Drainage Manual, Hydrology Standards, Volume II, December 1993.

1. Modifications in accordance with communications with Sacramento County Water Resources Division staff, August 12, 1994.

TABLE 4-4

BASIN "n" FOR UNIT HYDROGRAPH LAG EQUATION BY LAND USE AND EFFECTIVE PERCENT IMPERVIOUS

Sacramento County Land Use Description	Effective Percent Impervious	Basin "n"	
		Developed Pipe/Channel	Undeveloped Channel
Rural Estates	10	0.060	0.100
Rural Residential	15	0.056	0.096
Low Density Residential	30	0.046	0.088
Medium Density Residential	40	0.042	0.084
High Density Residential	70	0.035	0.073
High Rise Residential	80	0.032	0.070
Neighborhood Commercial	90	0.032	0.070
Community Commercial	90	0.032	0.070
Highway Service Commercial	90	0.032	0.070
Water-related Commercial	90	0.032	0.070
General Commercial	90	0.032	0.070
Office	90	0.032	0.070
Business Park	90	0.032	0.070
Mixed Use	60	0.037	0.076
Riverfront Mixed Use	60	0.037	0.076
Mixed Commercial/Industrial	85	0.032	0.070
Light Industrial	85	0.032	0.070
Heavy Industrial	85	0.032	0.070
Water-related Industrial	85	0.032	0.070
Public/Quasi-public	50	0.040	0.080
Recreation and Park	5	0.065	0.110
Open Space	2	0.075	0.120
Agriculture	2	0.075	0.120

Source: Draft Sacramento City/County Drainage Manual, Hydrology Standards, Volume II, December 1993.

TABLE 4-5

LAG MULTIPLICATION FACTORS FOR OVERLAND RELEASE

Frequency, yrs	2	5	10	25	50	100	200	500
Multiplication Factor[1]	1.0	1.0	1.0	1.1	1.2	1.3	1.4	1.5

[1] Lag multiplication factors to be applied to the lag times for developed piped areas with overland release.

Source: Sacramento City/County Drainage Manual, Hydrology Standards, Volume II, December 1996.

TABLE 4-6

NOLTE FORMULA CLASSIFICATIONS AND LAND USE PARAMETERS, I, BY LAND USE

Land Use Description	Nolte Formula Classification	Land Use Parameter, I
Rural Estates	R	-
Rural Residential	R	-
Low Density Residential	R	-
Medium Density Residential	R	-
High Density Residential	M	80
High Rise Residential	M	90
Neighborhood Commercial	C	-
Community Commercial	C	-
Highway Service Commercial	C	-
Water-related Commercial	C	-
General Commercial	C	-
Office	C	-
Business Park	C	-
Mixed Use	C	-
Riverfront Mixed Use	C	-
Mixed Commercial/Industrial	C	-
Light Industrial	C	-
Heavy Industrial	C	-
Water-related Industrial	C	-
Public/Quasi-public	M	60
Recreation and Park	R	-
Open Space	R	-
Agriculture	R	-

TABLE 4-7

MANNING'S "n" BY CONVEYANCE SYSTEM TYPE

Conveyance Type	Manning's "n"
Concrete Pipe	0.015
Corrugated Metal Pipe	0.024
Concrete-lined Channels	0.015
Earth Channel (Straight/Smooth)	0.022
Earth Channel (Dredged)	0.028
Mowed Grass-lined Channel	0.035
Natural Channel (Clean/Some Pools)	0.040
Natural Channel (Winding/Some Vegetation)	0.048
Natural Channel (Winding/Stoney/Partial Vegetation)	0.060
Natural Channel (Debris/Pools/Rocks/Full Vegetation)	0.070
Floodplain (Isolated Trees/Mowed Grass)	0.040
Floodplain (Isolated Trees/High Grass)	0.050
Floodplain (Few Trees/Shrubs/Weeds)	0.080
Floodplain (Scattered Trees/Shrubs)	0.120
Floodplain (Numerous Trees/Dense Vines)	0.200

Source: Sacramento City/County Drainage Manual, Hydrology Standards, Volume II, December 1996.

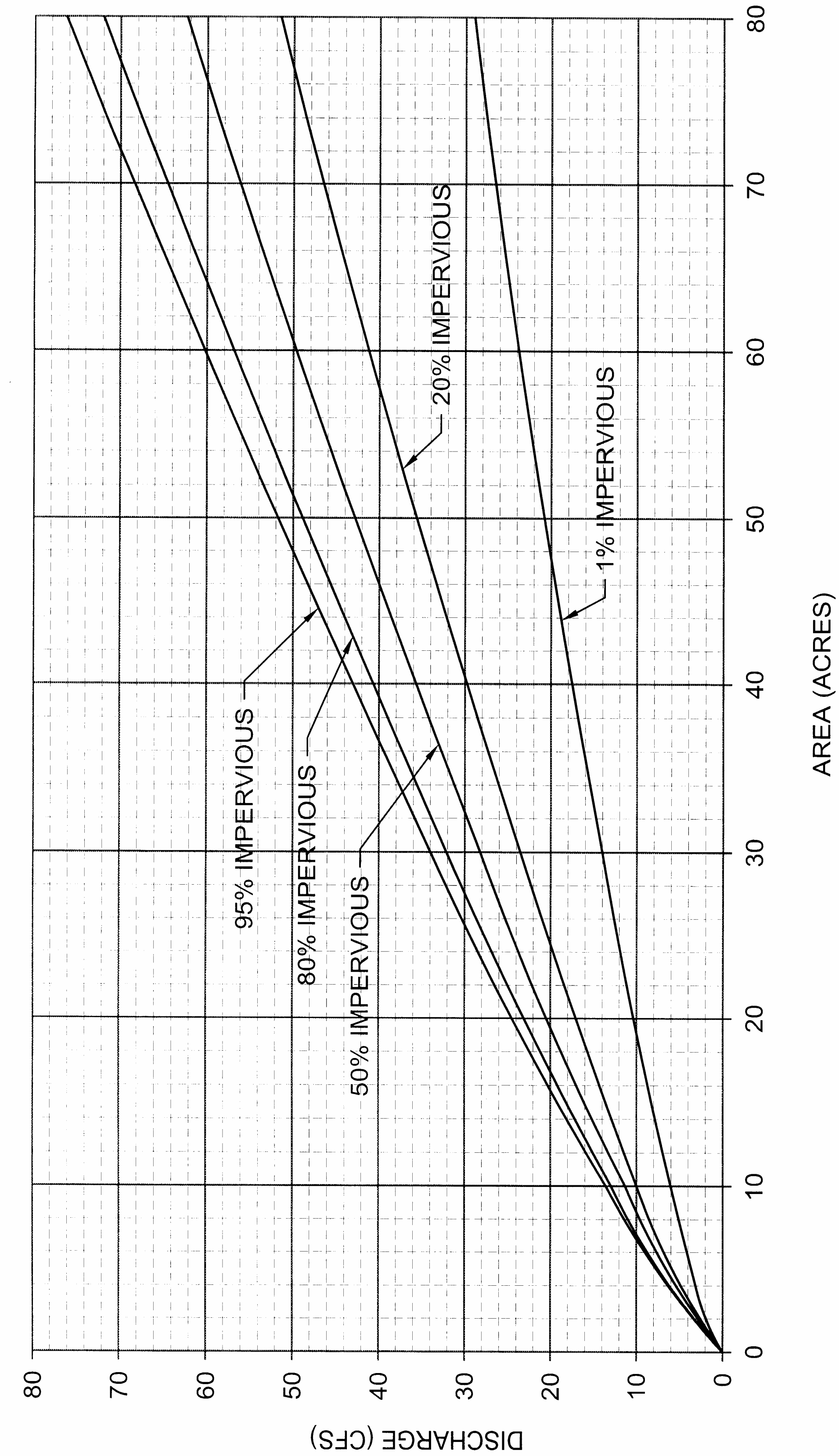

FIGURE 4-1

CITY OF WEST SACRAMENTO
DRAINAGE DESIGN FLOW STANDARDS ANALYSIS

10-YEAR PEAK FLOW
SACRAMENTO METHOD
RAINFALL ZONE 2, < 80 ACRES

SOURCE:

"SACRAMENTO CITY/COUNTY DRAINAGE MANUAL
VOLUME 1, HYDROLOGY STANDARDS," DECEMBER 1996.

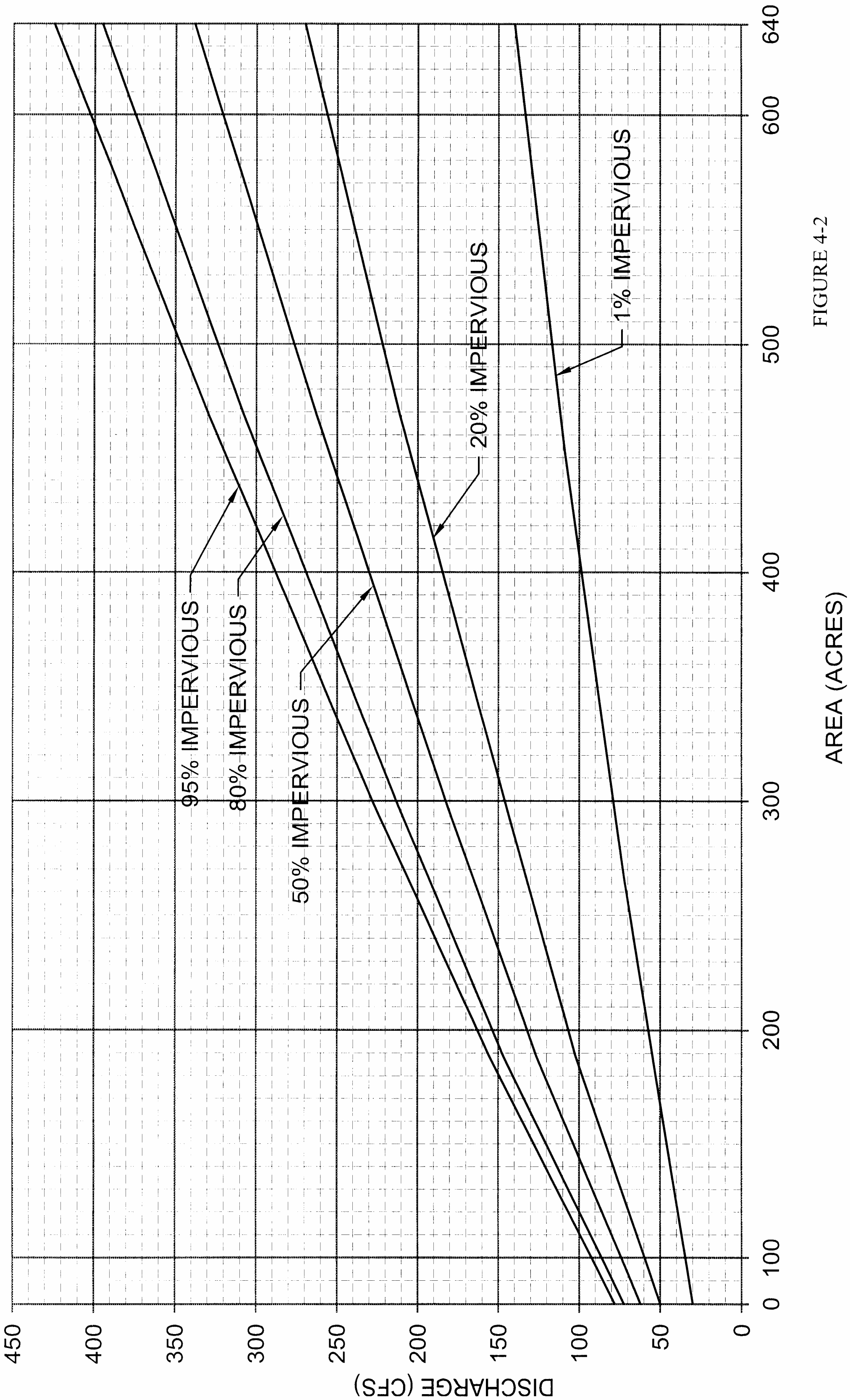

FIGURE 4-2

CITY OF WEST SACRAMENTO
DRAINAGE DESIGN FLOW STANDARDS ANALYSIS

10-YEAR PEAK FLOW
SACRAMENTO METHOD
RAINFALL ZONE 2, 80-640 ACRES

SOURCE:

"SACRAMENTO CITY/COUNTY DRAINAGE MANUAL
VOLUME 1, HYDROLOGY STANDARDS," DECEMBER 1996.

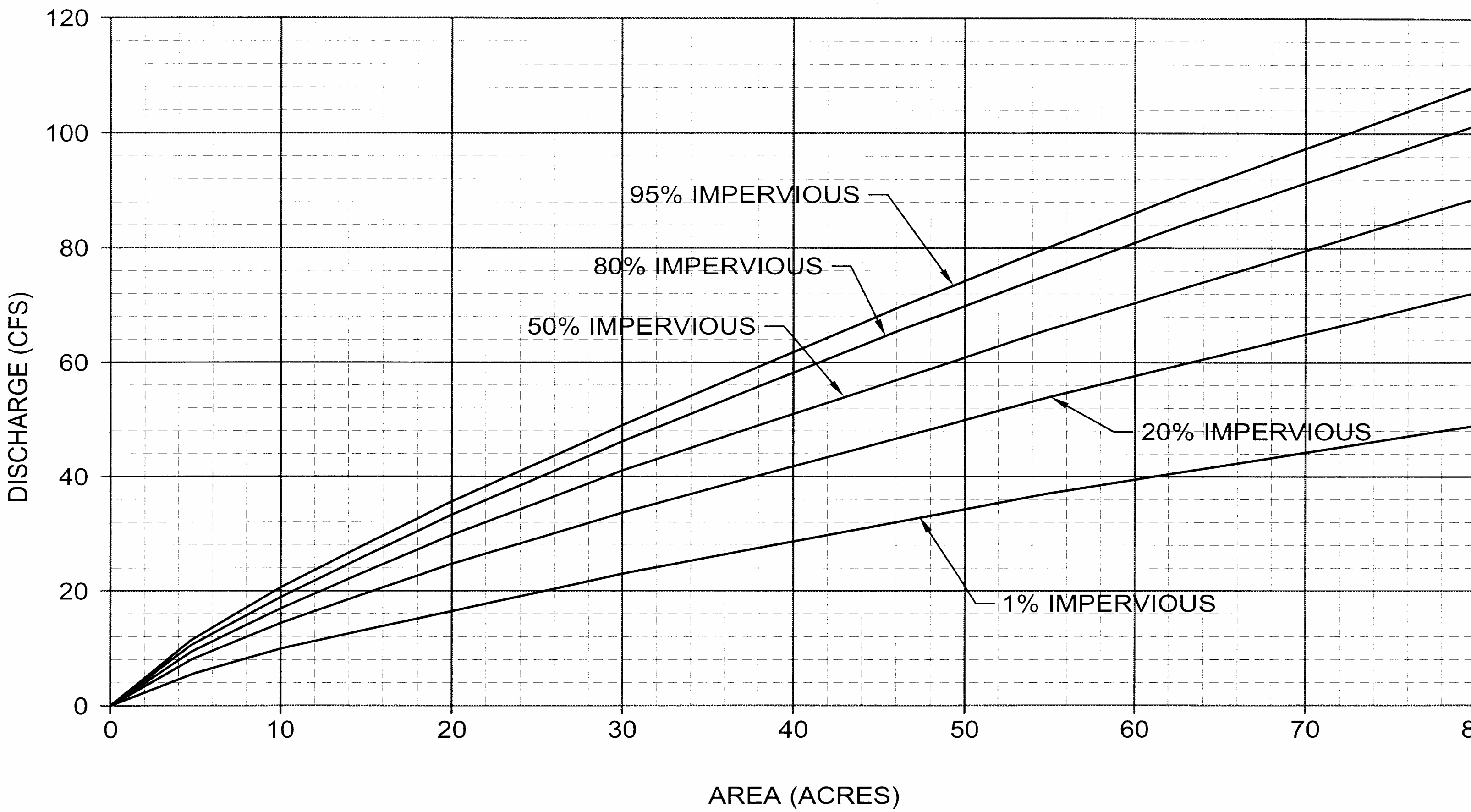

FIGURE 4-3

CITY OF WEST SACRAMENTO
DRAINAGE DESIGN FLOW STANDARDS ANALYSIS

100-YEAR PEAK FLOW
SACRAMENTO METHOD
RAINFALL ZONE 2, < 80 ACRES

SOURCE:

"SACRAMENTO CITY/COUNTY DRAINAGE MANUAL
VOLUME 1, HYDROLOGY STANDARDS," DECEMBER 1996.

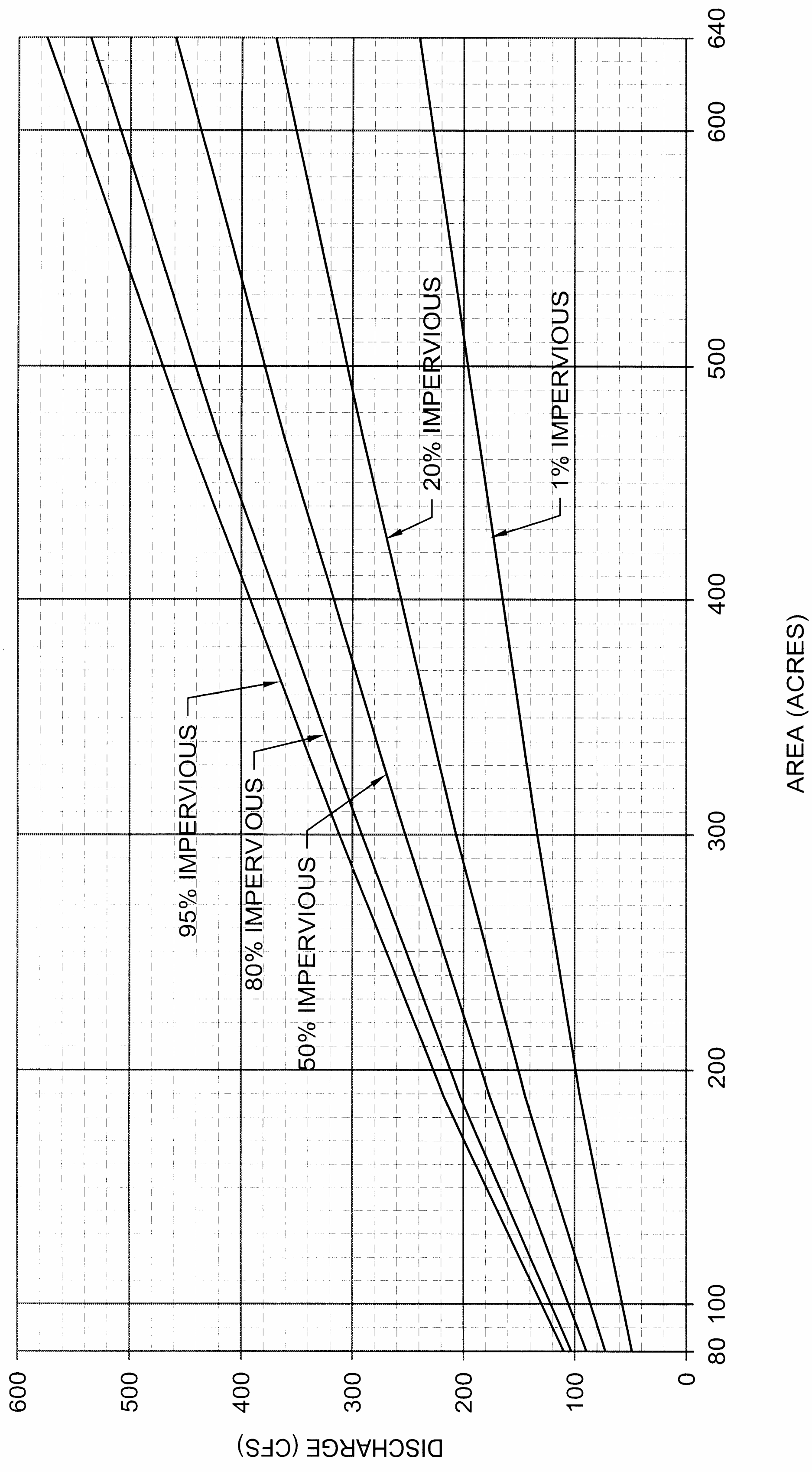

FIGURE 4-4

CITY OF WEST SACRAMENTO
DRAINAGE DESIGN FLOW STANDARDS ANALYSIS

100-YEAR PEAK FLOW
SACRAMENTO METHOD
RAINFALL ZONE 2, 80-640 ACRES

SOURCE:

"SACRAMENTO CITY/COUNTY DRAINAGE MANUAL
VOLUME 1, HYDROLOGY STANDARDS," DECEMBER 1996.

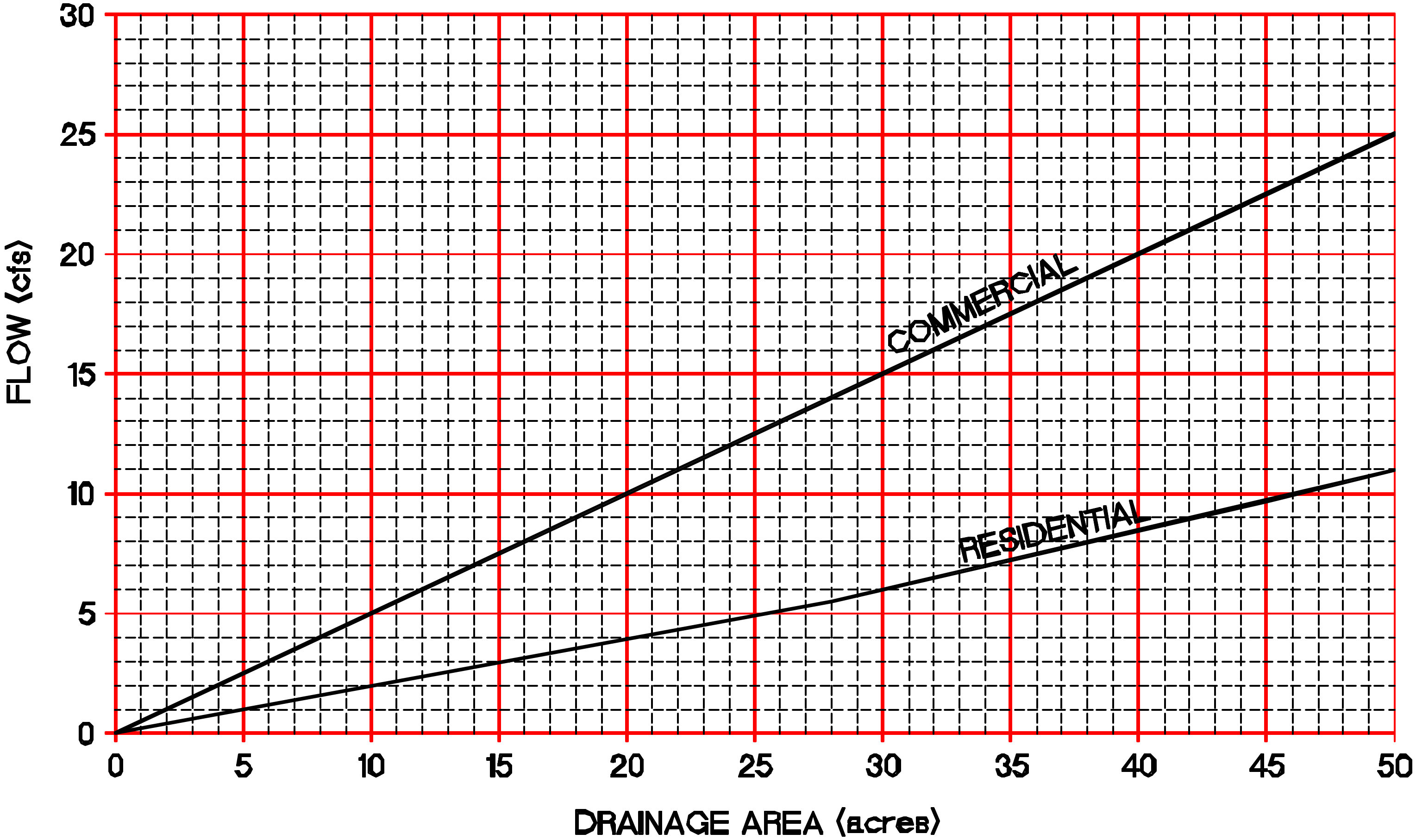

FIGURE 4-5

CITY OF WEST SACRAMENTO
DRAINAGE DESIGN FLOW STANDARDS

DESIGN RUNOFF
NOLTE METHOD
DRAINAGE AREAS, <50 ACRES

SOURCE:

"SACRAMENTO CITY/COUNTY DRAINAGE MANUAL
VOLUME 1, HYDROLOGY STANDARDS," DECEMBER 1996.

FIG. 4-5

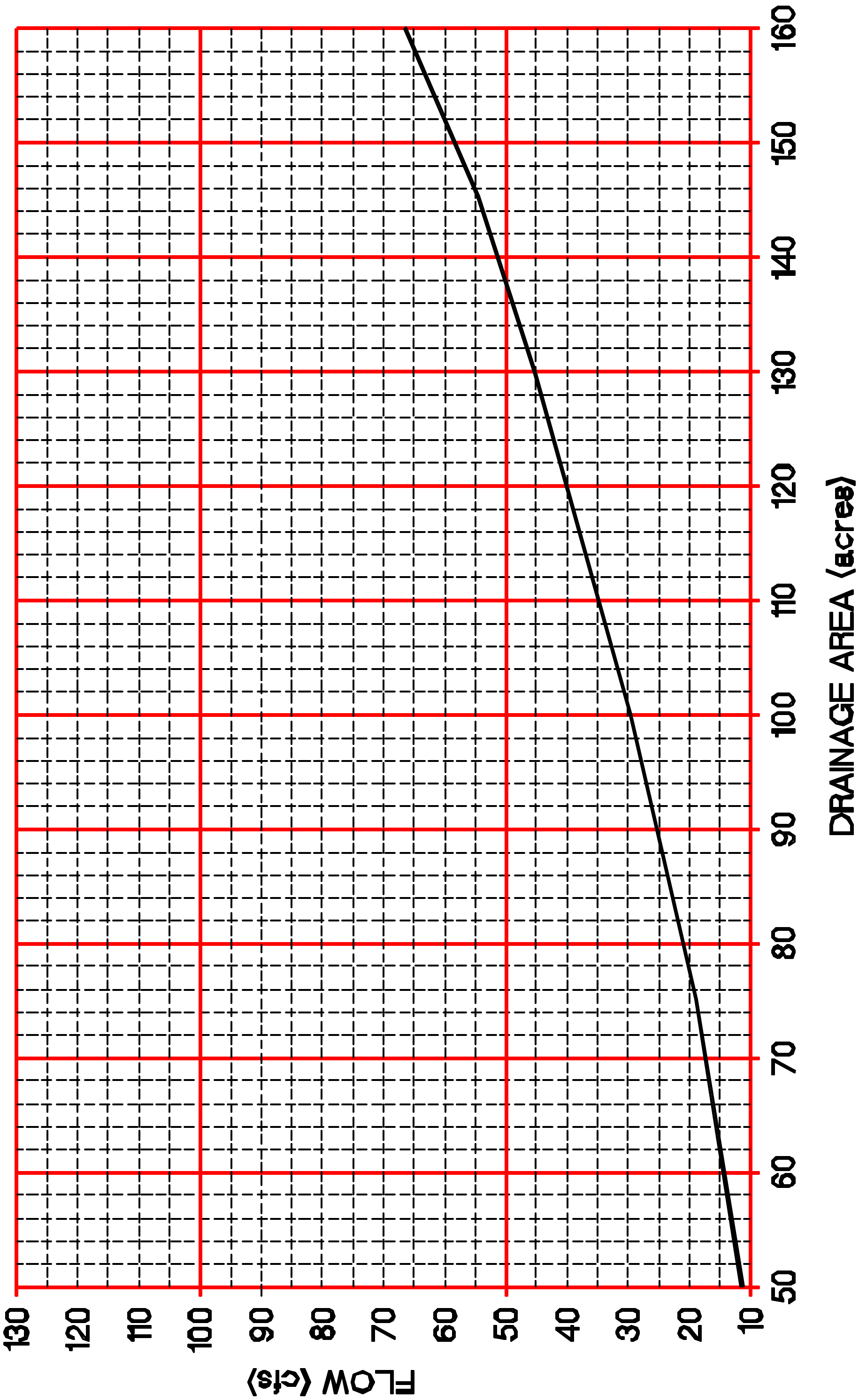

FIGURE 4-6

CITY OF WEST SACRAMENTO
DRAINAGE DESIGN FLOW STANDARDS

DESIGN RUNOFF
NOLTE METHOD
RESIDENTIAL AREAS, 50-160 ACRES

SOURCE:

"SACRAMENTO CITY/COUNTY DRAINAGE MANUAL
VOLUME 1, HYDROLOGY STANDARDS," DECEMBER 1996.

FIG. 4-6

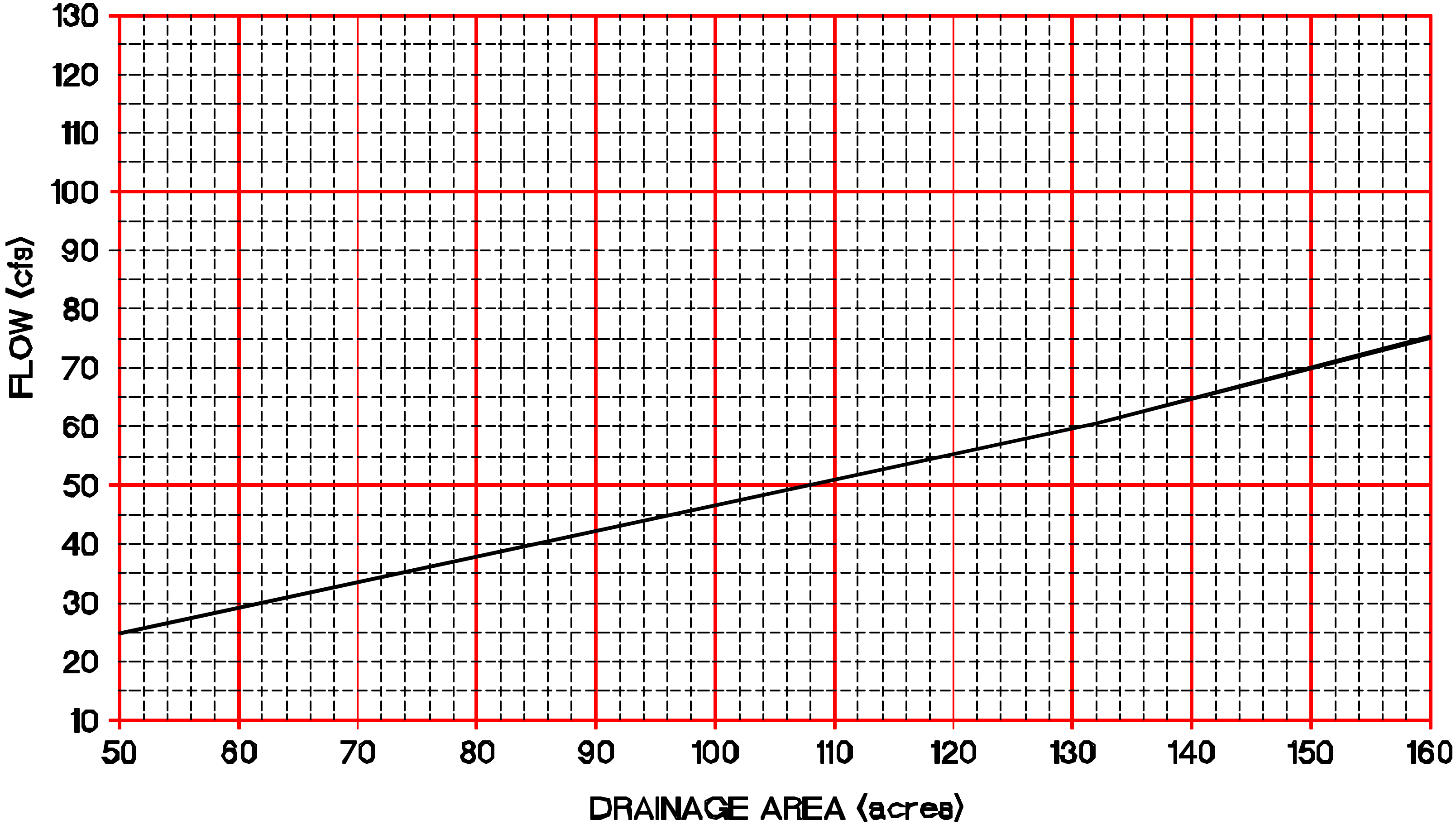

FIGURE 4-7

CITY OF WEST SACRAMENTO
DRAINAGE DESIGN FLOW STANDARDS

DESIGN RUNOFF
NOLTE METHOD
COMMERCIAL AREAS, 50-160 ACRES

SOURCE:

"SACRAMENTO CITY/COUNTY DRAINAGE MANUAL
VOLUME 1, HYDROLOGY STANDARDS," DECEMBER 1996.

FIG. 4-7

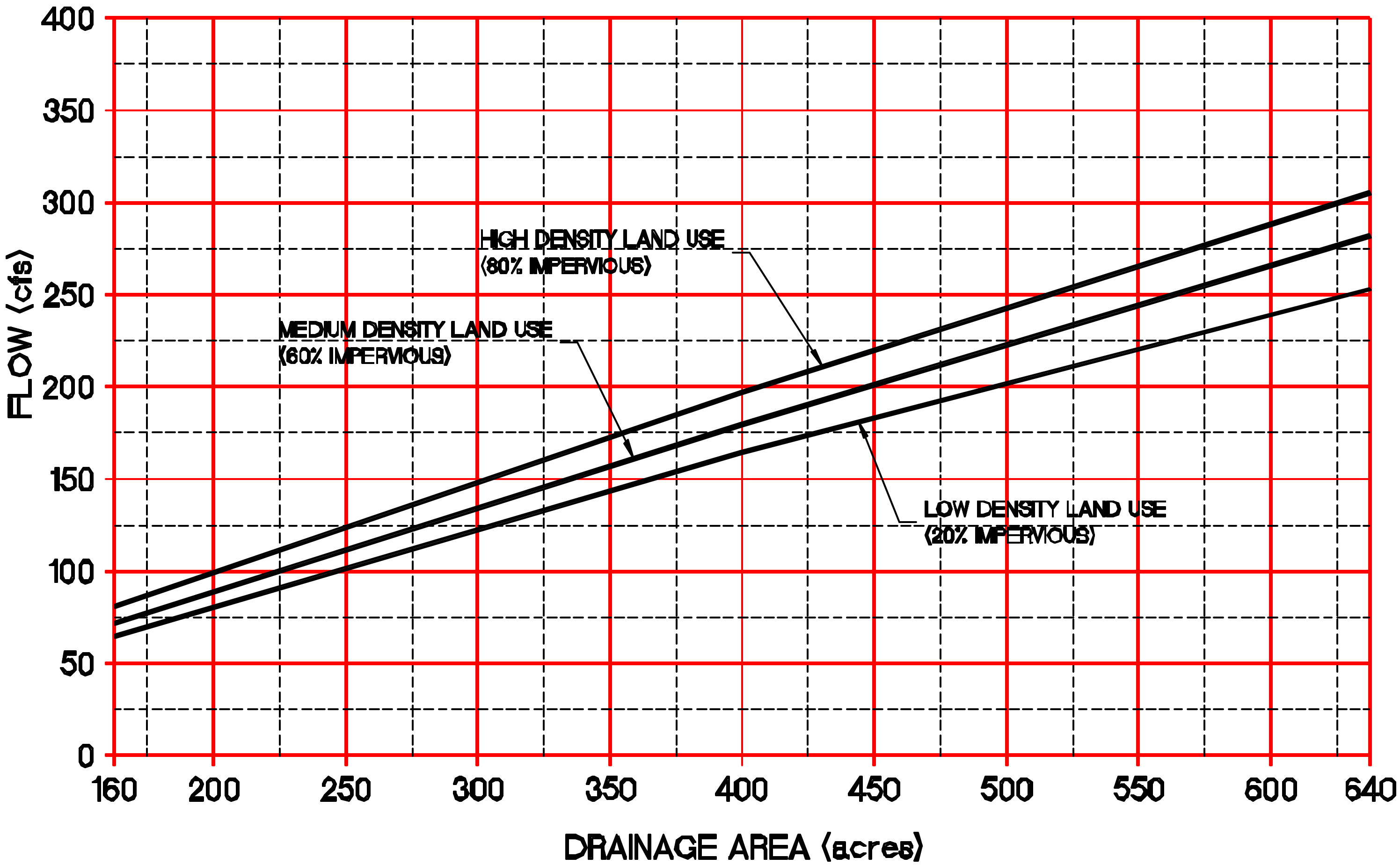

FIGURE 4-8

CITY OF WEST SACRAMENTO
DRAINAGE DESIGN FLOW STANDARDS

DESIGN RUNOFF
NOLTE METHOD
160-640 ACRES

SOURCE:

"SACRAMENTO CITY/COUNTY DRAINAGE MANUAL
VOLUME 1, HYDROLOGY STANDARDS," DECEMBER 1996.

FIG. 4-8

4.03 HYDRAULICS

A. GENERAL

1. All storm drain pipelines and open channels shall be designed for the above specified frequencies. For the 10-year frequency storm, storm drain pipelines shall be designed without static head at all entrances unless specifically permitted by the City Engineer. In no case will less than one (1) foot of freeboard be permitted between flow line of gutter and hydraulic gradient of the 10-year frequency design flow.
2. An overland release path for flows generated by a 100-year frequency storm shall be clearly delineated on the plans. Structural pad elevations shall be constructed a minimum of one foot above the highest top back of curb elevation across property frontage on public streets.

B. DESIGN CRITERIA

The following criteria shall be followed in all hydraulic computations unless otherwise approved in writing from the City Engineer.

1. Manning's formula shall be used to compute capacities of all open and closed conduits other than culverts.
2. King's formula shall be used to compute capacities of all culverts. (Refer to King's Handbook of Hydraulics and California Department of Transportation nomograph for the solution of King's formula).
3. The "n" values to be used in Manning's formula shall conform to the following:

   A roughness coefficient, n = 0.015 is used for sizing conduits when no allowance is made for minor losses (head loss at inlets, bends, junctions, expansions, etc.). If minor losses are accounted for, a roughness coefficient, n = 0.013 or per manufacturer's recommendations may be used.
4. Min. Inside Diameter - 12 inches
5. Min. Velocity - 2 feet per second when flowing full
6. Max. Velocity -Based on pipe or channel conditions and available head. (Generally 12-15 feet per second for pipelines).
7. The Engineer, in the design of the system, shall account for all losses in head at junctions, bends, manholes, entrances, and outlets, and at any other location where a change in direction or restriction to flow occurs which would tend to create a loss in available energy when required by the City Engineer.

4.04 ALIGNMENT

A. Pipelines for storm drainage shall be straight between manholes, junction boxes, and/or catch basins except under the following conditions:

   1. The inside pipe diameter is equal to or greater than 24 inches.

   2. Minimum radius of curvature is equal to or greater than 200 feet. In no case will the radius of curvature be less than the manufacturer's recommendations for the particular pipe size under consideration.

B. Drainage pipelines shall be located in the street whenever possible. The location of storm drainage pipelines in new streets shall be six (6) feet north or west of and parallel with the centerline of the street, unless otherwise approved by the City Engineer. Meandering and unnecessary angular changes of pipelines shall be avoided. Angular changes in alignment shall be no less than 90 degrees with the downstream section of the storm drain main.

C. All laterals intersecting with the mainline or manhole shall have an alignment that provides an angle of intersection with the downstream section of the storm drain main of no less than 90 degrees.

D. Joint deflection shall not exceed 80% of the manufacturer recommendations.

E. When a change in pipe diameter occurs, the top-of-pipe elevations of the inflow and outflow pipes shall match whenever possible.

4.05 COVER REQUIREMENTS

A. All storm drain pipe alignments shall be designed to allow a minimum of 2 feet of cover as measured from the top of finished grade to the inside top of pipe. If, for sound engineering reasons, 2 feet of cover cannot be obtained, the pipe shall either be encased in concrete or provided with a concrete cover as specified by the City Engineer.

4.06 APPURTENANCES

A. Manholes

   1. All storm drain manholes shall be constructed in accordance with the Standard Details.

   2. Manholes shall be located at junction points, changes in gradient, changes in conduit size and on curved alignments at the BC and EC of the curve and at no more than 300-foot intervals along the curve. For straight alignments, the spacing of manholes shall not exceed 500 feet.

   3. Whenever, at manholes, a change in the size of pipe, or a change in the alignment of 20 degrees or more occurs, the flow line of the incoming pipe shall be a minimum of 0.12 feet above the flow line of the outgoing pipe. The invert elevations in and out of the proposed manhole shall be shown on the improvement plans.

B. Junction Boxes

1. Junction boxes shall be constructed in accordance with the Standard Details. Junction boxes constructed on storm drainage conduits greater than 60 inches in diameter shall be of special design requiring approval by the City Engineer.

C. Saddle Manholes

1. All saddle manholes shall be constructed in accordance with the Standard Details. Saddle manholes will be allowed to be constructed on storm drain conduit 36 inches or greater in diameter provided that no junction exists with any other storm drain conduit at the manhole as determined by the City Engineer.

D. Catch Basins/Inlets

1. Catch Basins/Inlets shall conform to the Standard Details. Catch basins/inlets shall be designed and spaced such that they intercept and fully contain the 10-year storm. Catch basins/inlets shall be installed so that the length of flow in the gutter does not exceed 500 feet. All catch basin/inlets shall be stamped with the "Storm Drain Marker" as shown on Std. Detail 306.

E. Siphons

1. Inverted siphons will not be permitted.

F. Valley Gutters

1. Valley gutters will not be permitted to cross any streets, unless approved by the City Engineer.

G. Subdrainage

1. Subdrain facilities shall be provided when required by the City Engineer.

H. Box Culverts

1. Shall be required when specified by the City Engineer and designed on an individual basis.

I. Headwalls, Wingwalls, Endwalls, etc.

1. Shall be considered on an individual basis, and in general, designed in accordance with Section 51 of the State Standard Specifications.

J. Drainage Pump Stations

1. May be permitted on an individual basis with the written approval of the City Engineer.

4.07 OPEN CHANNELS

A. Definition

1. For the purposes of these Design Standards, a ditch shall be classified as an open channel when its capacity exceeds 25 cfs.

B. Design Criteria

1. Drainage may not be conveyed through a development in open channels without the written approval of the City Engineer. Open channels shall be designed in accordance with the following:

   a. Velocity range shall be 2.5 to 6.0 feet per second in unlined open channels and 3.0 to 12.0 feet per second in lined open channels.

   b. Channel lining shall be either finished concrete, sacked concrete, or doweled and sacked concrete. The minimum weight of sacked concrete shall be 60 pounds.

   c. All open channels shall be designed to carry the 100-year frequency flood. Per Section 4.02, the hydraulic grade line of the 10-year and 100-year storms shall be calculated and plotted on all channel profiles. All computations, including a narrative of the design shall be clearly documented and submitted to the City Engineer for approval.

   d. Freeboard shall be a minimum of 1.0 feet for the 100-year event and comply with the latest FEMA regulations.

   e. Side slopes shall be 3 feet horizontal to 1-foot vertical or flatter and the minimum bottom width of the channel shall be twice channel depth.

   f. Profile of existing channels for a minimum of 1,000 feet at each end of the development shall be shown on the construction plans to establish an average profile grade.

   g. Easement widths shall not be less than the width of the channel plus 4 feet on one side and 14 feet on the opposite side. A twelve-foot wide gravel road, serviceable for year around use, shall be constructed along one side of the channel.

   h. Special headwalls, endwalls, reinforced concrete transitions to culvert crossings, rip-rap, concrete aprons, energy dissipators, and other hydraulic devices shall be installed where required. All such devices shall be shown on the plans and approved prior to construction.

4.08 ROADSIDE DRAINAGE DITCHES FOR RURAL ROADS

A. Design Criteria

1. Ditches shall be designed in accordance with Section 4.02 of these Standards.

2. Roadside ditches shall not drain more than 1,500 feet parallel to the roadway.

3. Hydraulic gradients for roadside ditches shall be shown on the plans and shall be below the roadway structural section.

4. Driveway culverts shall be sized according to hydraulic calculations. Minimum size for the culvert shall be 12 inches and a minimum length of 20 feet. The driveway culvert shall be Class IV RCP or approved equal.

4.09 BENCH DRAINS AND DIVERSION DITCHES

A. Definition

A ditch shall be considered a bench drain or diversion ditch as long as its design capacity does not exceed 25 cfs. Any ditch, which has a capacity greater than 25 cfs, shall be considered an open channel and designed in accordance with Section 4.07. Diversion ditches will be allowed only upon approval of the City Engineer.

B. Design Criteria

Bench drains and diversion ditches shall be concrete lined and designed in accordance with the following:

1. Velocity range shall be 3.0 to 20.0 feet per second.
2. At changes in alignment and at inlets, adequate measures such as banking, circular curves or energy dissipators shall be used to confine water to the channel.
3. At locations where the overflow of a bench drain or diversion ditch could cause flooding, erosion or other damage, the channel section shall be designed to carry the 100-year runoff.

4.10 EASEMENTS

A. Requirements

Publicly owned drainage conduits and channels will not be allowed on private property unless they lie within a dedicated public easement. Where minor improvement of a drainage channel falls on adjacent property (such as daylighting a ditch profile) written permission from the adjacent property owner(s) for such construction shall be required. A copy of the document, which grants said approval shall be submitted to the City Engineer prior to the approval of the improvement plans.

B. Width

1. Easements for closed conduits shall meet both of the following width criteria:
   a. Minimum width of any easement for a closed conduit shall be 15 feet.
   b. All easements for closed conduits shall have a minimum width equal to the required trench width according to the standard detail for trench backfill plus 2 additional feet of width for every foot of depth of the pipe as measured from the bottom of the pipe to finished grade. All conduits shall be centered within their easements.
2. Drainage easements for open channels shall have sufficient width to contain the open channel plus a 14-foot wide right of way width on one side and a 4-foot wide right of way on the opposite side. The toe of a bank shall not be within 5 feet of an easement boundary. Easement boundary lines shall, at changes in alignment, have a radius sufficient enough to provide turning room for vehicles operating on the service road.