TECHNICAL MEMORANDUM

STORM DRAIN SYSTEM DESIGN

&

EVALUATION CRITERIA

For

CITY OF YREKA

By

WILLDAN

July 14, 2006

STORM DRAIN SYSTEM DESIGN & EVALUATION CRITERIA

I GENERAL

Storm drainage improvements shall be designed to serve the ultimate development level as defined in the current City General Plan and the current Storm Drainage Master Plan.

Although these standards are intended to apply to physical development within the City, the standards may not apply for all situations. Compliance with these standards does not relieve the Engineer of the responsibility to apply conservative and sound professional judgment. These are minimum standards and are intended to assist, but not substitute for competent work by design professionals. The City may, at its sole discretion due to special conditions and/or environmental constraints, require more stringent requirements than would normally be required under these standards.

The Engineer may propose a deviation from the Standards. A non-standard system may take longer to review. The Engineer acknowledges these risks when submitting a non-standard system for review.

The City's decision to grant, deny, or modify the proposed deviation shall be based upon evidence that the deviation request meets the following criteria:

A. The change will achieve the intended result through a comparable or even superior design; and

B. The change will not adversely affect safety and/or operation; and

C. The change will not adversely affect maintainability.

II PLAN AND CALCULATION REQUIREMENTS

All storm drainage improvement plans shall show geometric designs including plan and profile views, utility crossings, catch basins, laterals, manholes and invert elevations at all structures. In addition, the hydraulic grade line shall be shown on the storm drain profile.

In addition to the above, design computations for all drainage system projects shall include the following information:

A. <u>Drainage Analysis</u>:

1. Topographic map showing existing and proposed ground contours and total and sub-shed areas in acres. The project boundaries within the drainage basin shall be indicated on the map. The project area shall be divided into sub-basins for each drainage inlet.

2. Quantity of flow in cubic feet per second (cfs) to each structure with corresponding area that generates the quantity.

3. Time of concentration calculations for each structure.

4. Intensity of rainfall calculations for each structure.

5. Quantity of flow (cfs) in each pipe.

6. Flow line elevation of manhole or structure.

7. Average groundwater elevations.

8. Top of structure elevation.

9. Hydraulic grade line elevation at each structure.

10. Hydraulic gradient.

11. Pipe size, class, length and slope between structures.

12. Gutter capacity immediately upstream of each inlet.

13. Catch basin inlet capacity.

14. Overland flow release route for 100-yr storm identified.

B. Table of Values:

Provide a Table of Values, with neat and legible calculations, demonstrating that all of the required information noted in Section "A" above has been considered.

C. Detention Analysis

Provide a report stamped and signed by a California registered civil engineer analyzing pre- and post development project flow rates. Provide calculations substantiating the metering capabilities of the detention structure.

III FACILITIES CLASSIFICATIONS

For the purpose of presentation and design, the following classifications will be used in defining storm drainage facilities:

A. Minor: Drainage facilities receiving runoff from an area of less than 30 acres shall be called a minor system.

B. Trunk: Drainage facilities receiving runoff from an area of 30 acres or larger shall be called a trunk system.

C. On-Site Drainage: Drainage facilities needed to carry runoff within the development, excluding trunk drainage conduits, facilities draining public streets, and facilities draining concentrated flow from other properties shall be called on-site drainage.

IV DESIGN CAPACITIES

Drainage facilities shall be designed to accommodate the future development of the entire upstream watershed. The future development shall be defined as full buildout of the General Plan Land Use Designations.

The capacity design criteria for storm drainage facilities are as follows:

A. Storm Drain: Closed conduit storm drain systems shall be designed to convey the ten (10) year storm event while maintaining the hydraulic grade line at least one (1) foot below the elevation of inlet grates and manhole covers.

B. Open Channel: Open channels shall be designed to convey the 100-year storm event while maintaining at least one (1) foot of freeboard in cut sections and three (3) feet of freeboard in levied sections.

C. Bridges: Bridges shall be designed to pass the 100-year storm while maintaining a minimum of one (1) foot of freeboard to the low chord.

D. Culverts: Culverts shall be designed to pass the channel design capacity while meeting freeboard requirements.

E. Local Detention Facilities (LDF): LDF's are designed to reduce peak flows in accordance with the Section V.

F. Roof, Footing and Yard Drains, Commercial and Residential (as applicable): Roof and footing drain pipes shall be separate lines which may only be joined as a non-perforated pipeline at an elevation at least one (1) foot below the lowest footing drain invert elevation. The minimum cover over the storm drain stub at the property line shall be two (2) feet. Clean-outs (4-inch minimum diameter) with factory manufactured fittings, shall be provided at all junctions and bends greater than 45 degrees. The maximum spacing between clean-outs shall not exceed 100 feet. Roof, footing and yard drains shall not be connected to the sanitary sewer system. Roof, footing and yard drains shall not be located within the public right-of-way except where connecting to the municipal drainage system. Roof, footing and yard drain systems shall be directed to discharge into the public storm drain, Public Way, or other approved storm drain discharge point. Where it is impossible or impractical for the roof, footing, and/or yard drain systems to discharge directly to an approved discharge location without crossing or serving more than one parcel such roof, footing, and/or yard drain systems shall be within private utility easements, and all responsibility for the maintenance, repair, or replacement of such drains and drain systems shall be the responsibility of the property owners. Corrugated polyethylene tubing (CPT) may not be used in the Right-of-way, or for any other purpose except as a privately owned and maintained overbank drain.

Maintenance: Roof, footing and yard drainage systems, drainage systems on commercial and multifamily properties, drainage facilities within private easements, and drainage facilities otherwise denoted as private, shall be designed to provide access for maintenance and operation by the owners of such facilities.

V STORM DRAINAGE CALCULATIONS

Three methods of estimating design storm drainage flows are allowable. Methods, applications and locations of additional information are summarized in Figure X2.

Storm drainage system design calculations are to be submitted to the City in bound form and in electronic form (Microsoft Excel format). The submittal package shall be stamped and signed by a California registered civil engineer. Calculations using the Rational Method shall be submitted on standard forms (see Figure X4) and on computer disk in Excel format, for all storm drainage improvements including trunk lines, laterals, curb inlets and open channels proposed in connection with new development projects.

The calculations based on the Rational Method for infill development areas limited up to 640 acres shall be as follows:

The Rational Method equation has the form: $Q = CiA$

Where:

Q = rate of runoff, acre-inches per hour or cubic feet per second (acre-inch per hour = 1.008 cubic feet per second, a negligible difference);

C = runoff coefficient, which is the ratio of peak runoff to average rainfall intensity;

i = average rainfall intensity, inches per hour (from the Siskiyou County Hydrology Manual); and

A = drainage area, acres.

The Rational Method shall be applied using the procedure outlined below.

A. Basic Information Preparation: Layout the proposed storm drain system and delineate the sub-basins tributary to points of concentration for the design of inlets, junctions, pipelines, etc. Delineate the land uses and hydrologic soil groups within each sub-basin.

B. Runoff Coefficient Determination: The runoff coefficients, C, are presented in Figure X5 by land use designation and hydrologic soil group.

C. Time of Concentration Determination: The time of concentration or the travel time is the time required for runoff to flow from the most upstream point of the drainage area through the conveyance system to the point of interest. The travel time is calculated by dividing the length of the conveyance system component by the corresponding velocity of flow. The travel time, Tc, is computed as follows:

$T_c = T_o + T_g + T_p + T_{ch}$

Where:

T_o = overland flow time of concentration;

T_g = gutter flow travel time;

T_p = pipe flow travel time; and

T_{ch} = channel flow travel time.

The equation used to compute the travel time for each conveyance component is described below.

D. Overland Flow: The recently developed Kinematic wave empirical equation based upon available SCS, COE, and FAA overland flow data (Papadakis, 1987) is:

$$T_o = \frac{0.66 L^{0.50} n^{0.52}}{S^{0.31} i^{0.38}}$$

Where:

T_o = overland flow time of concentration, minute;

L = overland flow length, ft,

n = roughness coefficient for overland flow

S = average slope of flow path, ft/ft; and

i = intensity of precipitation, in/hr

Use of the overland time of concentration equation requires an iterative approach: an initial estimate of the time of concentration updated by successive estimates of precipitation intensity.

E. Gutter Flow: Manning's equation for a triangular channel cross section is used to determine the flow velocity and travel times for street gutter flow.

The average distance from the overland flow surface to the nearest inlet is divided by flow velocity to obtain street gutter flow time. The gutter flow equation was derived using the following assumptions:

- The cross slope of the street is 0.02 ft/ft.
- The flow in the gutter is six inches deep and contained by the curb.
- The street surface is smooth asphalt or concrete.

The velocity of flow in the gutter is computed by the equation:

$$V_g = \frac{1.12}{n} S_x^{0.67} S^{0.50} T^{0.67}$$

Where:

V_g = velocity of flow in the gutter, ft/s;

S_x = street cross slope, ft/ft, design value = 0.02;

S = street longitudinal slope, ft/ft;

T = spread of flow in gutter = d/S_x, ft;

d = depth of flow in the gutter, ft, design value = 0.5 ft; and

n = Manning's "n" for pavement, design value = 0.02.

F. Pipe Flow: Manning's equation can also be used to determine travel time of flow through pipes. Travel time is usually calculated by assuming full pipe flow. Flow velocity is calculated with the equation:

$$V = \frac{1.49}{n} R^{0.67} S^{0.50}$$

Where:

V = velocity in pipe, ft/s;

R = hydraulic radius, D/4 for full pipe flow, ft;

D = diameter of pipe, ft;

S = slope, ft/ft; and

n = Manning's "n"

G. Intensity Determination: The rainfall intensity shall be determined from the rainfall intensity duration curve using the computed time of concentration.

H. Antecedent Moisture Condition: Calculations for establishing storage quantities for detention facilities shall be based on Antecedent Moisture Condition (AMC) 2 irrespective of return duration storm being analyzed.

VI LOCAL DETENTION FACILITIES

Unless a functioning regional detention facility serving the subject property has been previously constructed, local on-site detention facilities shall be provided to reduce post development peak flow rates to pre-project flow rates. Temporary underground detention facilities may be designed for use while permanent storm drainage facilities are being completed.

Detention facilities shall be designed in accordance with Section 5.4 “Conditions of Development” of the City of Yreka’s Master Plan of Drainage prepared by Willdan dated June 2005. The specific design elements for the detention facility shall be established on a case-by-case basis. The design may vary depending upon whether or not the particular facility is permanent or temporary, or is a dual or multi-purpose facility, with drainage, water quality, and possibly recreational components. Detention facilities shall be designed according to State Division of Safety of Dams.

In general, detention facilities shall be analyzed utilizing a hydrograph methodology that compares the quantity of pre-development runoff to the post-development runoff for the 100-year storm event to determine the required size of the detention facility. The final design of the detention facility must include the submission of the following three items:

- Inflow hydrograph
- Stage vs. storage curve
- Stage vs. discharge curve (sometimes called a performance curve)

Detention facilities shall be designed with spillway features to conduct excess flows into streets. Overland flow through streets shall not adversely impact areas downstream.

Numerous tools are commercially available for creating hydrograph models. Along with commercially available software programs, the United States Army Corps of Engineers has “HEC-HMS” available as a free download along with complete documentation. HEC-HMS and its associated manuals may be obtained found at the following Army Corps web site:

http://www.hec.usace.army.mil/software/hec-hms/

Small Lot Detention Basin Design

Infill development or redevelopment of small lots of ½-acre or less in size, where no off-site drainage or drainage courses contribute to or are conveyed through the lot, may use the hydrograph methodology noted above for the design of detention facilities, or may use the alternate method outlined in this section.

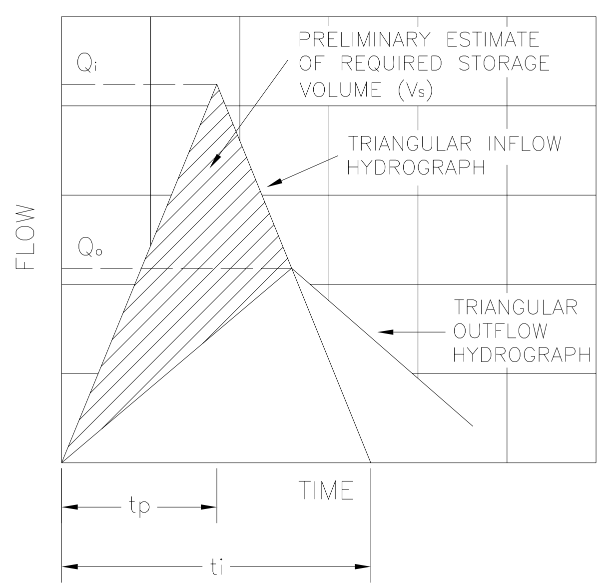
Detention facilities for small lots may be designed utilizing the Triangular Hydrograph Method as outlined in Section 8.4.1.2 of the FHA publication HEC-22, "Urban Drainage Design Manual". The required storage volume may be estimated from the area above the outflow hydrograph and inside the inflow hydrograph as defined by the equation below:

$$V_s = 0.5 t_i (Q_i - Q_o)$$

where:

V_s = storage volume (ft^3)
Q_i = peak inflow rate into the basin (ft^3/sec)
Q_o = peak outflow rate out of the basin (ft^3/sec)
t_i = duration of basin inflow (sec)
t_p = time to peak of the inflow hydrograph (sec)

When utilizing this simplified method for the design of detention facilities, the time to peak flow shall be considered as one half the time of concentration.



Triangular Hydrograph Method

VII SEEPAGE IN TO/OUT OF DETENTION FACILITIES AND OPEN CHANNELS

The seepage of groundwater into or out of the detention facilities and open channels shall be evaluated based upon available groundwater information and driller logs to determine if inflow of groundwater into drainage facilities would affect design capacities or operations.

VIII HORIZONTAL ALIGNMENT

Storm drainage lines may be located parallel with the centerline of streets, with the centerline of the pipe 5.00 feet from the face-of-curb into the street. Large angular changes over five degrees (5°) in the alignment of storm drains are not allowed without the use of a manhole.

IX HYDRAULIC GRADE LINE

Hydraulic grade lines shall be a minimum of one-foot (1') below the elevation of inlet grates and manhole covers and shall be shown on improvement drawings.

X CURB INLETS

The spacing of storm drain inlets shall not exceed a maximum of 500 feet. Drainage inlets shall be located to prevent surface flow through street intersections. Stormwater inlets in a roadway shall be located in the curb line, and shall only be through curb inlet design in accordance with City standards.

XI STORM DRAINAGE PIPE

Storm drainage pipe shall be reinforced concrete pipe, non-reinforced concrete pipe, cast-in-place concrete pipe, HDPE, or PVC as specified in the City's Construction Standards. Other types of conduit (arch culvert, box culvert, etc.) will be considered upon submittal to City Engineer.

Where cast-in-place concrete pipe (CIPCP) is proposed, the soils report for the project shall address CIPCP placement. A California registered civil engineer shall provide details to the City for connection of CIPCP to different piping materials as are proposed and affected.

XII COVER

All storm drainage pipes shall be installed with a minimum cover of two feet (2') and a maximum cover of 15'. In any instance where the distance from the paving surface to the top of pipe is less than 24 inches, a six-inch (6") thick reinforced concrete slab shall be placed over the pipe for protection (slab to overlap pipe on each side by 12 inches min.)

XIII MANHOLES

Spacing between manholes shall be a maximum of 500-feet for pipe sizes of 48-inches and under. For pipes 54-inches and larger, the City Engineer shall approve the manhole spacing. When a catch basin, manhole, or concrete inlet is located off the traveled portion of the roadway or under other conditions of limited surveillance, the grate or cover shall be bolt locking.

Manholes shall be located at all changes in pipe sizes or slopes, at angles greater than twenty degrees (5°) and at all lateral connections. A curb inlet shall be sufficient as a manhole when the connecting upstream lateral serves only one additional curb inlet. Manholes shall be required at the junction of all lines, except at curb inlets as described.

Crowns of pipe shall match in elevations at manholes. Curb inlets may be considered as manholes if provided with a forty-eight inch (48") diameter or larger riser barrels. See Standard Plans for a curb inlet manhole design.

On curved pipes with a radius of 200-feet to 400-feet, manholes shall be placed at the beginning of curve (B.C.) and ending of curve (E.C.) and at a maximum interval of 300-feet along the curve. On curves with a radius exceeding 400-feet, manholes shall be placed at the B.C. and E.C. and at 400 foot maximum intervals along the curve for pipes 24 inches and less in diameter; and 500 foot maximum intervals along the curve for pipes greater than 24 inches in diameter.

XIV MINIMUM SIZE OF STORM DRAINS

Storm drain mains and laterals connecting inlets to mains shall not be less than fifteen inches (15") in diameter. Exceptions are subject to approval by the City Engineer.

XV VELOCITY

All storm drain lines shall be designed to flow with a minimum velocity of two feet (2') per second when flowing half full.

XVI EASEMENTS

General: Drainage facilities that are constructed to serve predominantly public property or public right-of-way shall be publicly owned and shall be dedicated to the City.

Where possible, public conveyance systems shall be constructed within the public right-of-way. When site conditions make this infeasible, public utility easements (minimum 20 foot width) or dedicated tracts shall be provided. Private drainage facilities shall be constructed outside of the public right-of-way, on private property.

Easement Documentation Requirements: All easements shall be shown on the project plans and shall be designated with either “private” or “public”. All property documentation shall be properly executed. Easement/tract documents shall include a map, the Siskiyou County Assessor number of affected properties and owners' names.

Easements shall be dedicated to and approved by the City prior to acceptance of a public drainage system. Grantee shall be the "City of Yreka, a municipal corporation, its heirs, successors, or assignees." Indemnification and hold harmless agreements to hold the City harmless shall be included in recorded documents where maintenance access across private property and/or pumping of storm drainage is deemed necessary by the City.

Bills of sale for all drainage facilities appurtenant to public easements or tracts shall be given to the City with the executed real property documents that transfer property rights to the City. Grantor shall pay all title policy and recording fees necessary to transfer rights to the City.

A. Drainage Facilities: All drainage facilities other than on-site systems shall be located in one of the following:

    1. Public street or alley.

    2. Public utility easement (20 foot minimum width), specifically dedicated to include drainage facilities.

    3. Dedicated drainage easement (20 foot minimum width).

B. Closed Conduits: closed conduit easements shall meet the following requirements:

    1. For pipes under 24 inches in diameter, minimum width of twenty feet with the centerline of the pipe at quarter point; pipe may reverse sides at angle points.

    2. For pipes exceeding 24 inches in diameter or trenches exceeding five feet in depth, the easement width shall be 20 foot minimum width or shall be based upon the following formula (whichever provides the greater width):

       WIDTH = Trench Depth + Pipe Diameter + Two Feet

    3. For pipes in side- and/or back-lots in a subdivision, a minimum width of twenty feet.

C. Open Channels: Easements for open channels shall have sufficient width to contain the channel, fencing where required, and a fifteen-foot service road.

XVII TRENCH DRAINS

Trench drains shall not be utilized for public or private drainage systems. Private developments shall be connected directly to the City underground storm drain system or graded to drain into street side surface drainage system.

XVIII STUB END PIPES

All stub end pipes shall be plugged with a pre-fabricated watertight plug.

XIX OPEN CHANNELS

Requirements for open channels are as follows:

A. Drainage: Drainage may be conveyed through an open channel with prior written approval of the City Engineer.

B. Construction: Channels shall be constructed to a typical cross section. Fully lined channels shall be designed with maximum side slopes of 1:1; channels with unlined sides shall be designed with maximum side slopes of 3:1. Lined channels shall have a minimum bottom width of six feet (6') and shall have adequate access ramps for maintenance equipment.

C. Design: Channels shall be designed to convey the design flow with a minimum velocity of two feet per second (2 fps). The maximum velocities shall be as follows:

  1. Earth channels, six (6) fps.

  2. Fully lined channels, ten (10) fps.

  3. Bottom only lined channels, eight (8) fps.

D. Curve Radius: The centerline curve radius of an open channel shall be equal to or greater than twice the bottom width (35-foot minimum).

XX RETENTION PONDS

Retention ponds are generally prohibited. The City Engineer may consider retention pond, case-by-case.

XXI LEVEES

Where new levees are constructed, the land side levee slope will be 2:1. The water side slope of the new levee embankment will be constructed at 3:1. The top width of the levee beam will be fifteen feet and will also function as a patrol road. The limits of the right-of-way will extend ten feet beyond the toe of the land side slope of the new levee embankment to provide access for levee maintenance.

XXII SLOPE PROTECTION

Where channel slope protection is required, stone riprap protection shall be designed in accordance with FEMA Standard EM 1110-02-1601, “Hydraulic Design of Flood Control Channels”.

XXIII STRUCTURE OPERATION CRITERIA

All structures such as ponds, control gates, weirs, flap gates, temporary facilities, etc., shall be shown in detail on design and construction drawings. Their purpose, functional operation parameters and settings shall be described on the drawings. Pond ownership and maintenance responsibilities shall also be included.

XXIV DRAIN INLETS

Storm drain inlets located in non-paved areas shall utilize 24" x 24" minimum galvanized steel grate set horizontally and be surrounded by six inch (6") cobble one-foot (1') in depth and six feet (6') in radius. Cobble may be sloped no steeper than 3:1.

FIGURE X1

HYDROLOGIC SOIL GROUPS

Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D.

Details of this classification can be found in ‘Urban Hydrology for Small Watersheds’ published by the Engineering Division of the Natural Resource Conservation Service, United States Department of Agriculture, Technical Release–55.

Group A: Low runoff potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well-drained sands or gravels. These soils have a high rate of water transmission.

Group B: Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained sandy- loam soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C: Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of silty-loam soils with a layer that impedes downward movement of water, or soils with moderately-fine to fine texture. These soils have a slow rate of water transmission.

Group D: High runoff potential. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

FIGURE X2

METHODS FOR ESTIMATING DESIGN FLOW

APPLICATION	METHOD	MAXIMUM BASIN SIZE	DESIGN PARAMETER	REFERENCES
Design of: * Street Drainage * Storm Drains * Culverts not Associated With Channels	Rational	640 ac	Flow	
Master Plans or Designs of: * Storm Drains * Open Channels * Bridges and Culverts * Detention Basins	HEC-1, Runoff Block of SWMM	No Limit	Flow and Volume	
Water Quality Detention Basins	HEC-1, Runoff Block of SWMM	No Limit	Volume	

FIGURE X3

MANNING’S 'n' FOR CHANNEL FLOW

LAND USE DESCRIPTION	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/Stony/Partial Vegetation	0.048
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: Draft “Sacramento City/County Drainage Manual, Hydrology Standards Volume II,” December 1996 and City of Redding Standard Specifications.

FIGURE X4

STORM DRAIN CALCULATIONS - RATIONAL METHOD

Roof to gutter time ______________ Job Name ________________________________ Date ____________________

Manning's 'n' value ______________ Job Number __________________________ Designer ____________________

Page ______ of ______

Pt. of Conc.	Area Desig.	Area (acres)	Runoff Coeff.		Accumulated		Time of Conc.	Rainfall Intensity	Runoff Q	Conduit Size	Slope SL	Length L	Velocity VEL	Time in Section	Minimum Curb Data				
					ΣA	$\Sigma(AxC)$									H = SL x L	Elev. HGL	Elev. EGL	MTC HGL x 1.25	Design TC
		A	C	A x C	(acres)		(min.)	i	(cfs)	(in.)	(ft./ft.)	(ft.)	(fps)	(min.)					

NOTE: This spreadsheet is electronically available for conducting storm drainage calculations from the Public Works Department upon request. Please include your email address with your request.

FIGURE X5

LAND USE VS. EFFECTIVE PERCENT IMPERVIOUS AND RUNOFF COEFFICIENTS FOR THE RATIONAL METHOD

Land Use from Aerial Photography	General Plan Land Use Designation	Effective % Impervious	Runoff Coefficient by Hydrologic Soil Group		
			B	C	D
Highways, Parking	Central Commercial (CC)	95	0.86	0.87	0.87
Commercial, Office	General Commercial (GC); Service Commercial (SC); Highway Commercial (HC); Business Park (BP)	90	0.82	0.84	0.85
Industrial	Industrial (I)	85	0.78	0.80	0.82
Apartments	N/A	80	0.74	0.77	0.79
Mobile Home Park	N/A	75	0.70	0.74	0.76
Condominiums	Med. Density Residential (MDR)	70	0.66	0.71	0.74
Residential: 8-10 du/acre	Medium/Low Density Residential (MLDR)	60	0.58	0.64	0.68
Residential: 6-8 du/acre	Neighborhood Preservation (NP); Planned Neighborhood (PN)	50	0.50	0.58	0.63
Residential: 3-4 du/acre	N/A	30	0.34	0.45	0.52
Residential: 2-3 du/acre	Very-Low Density Residential (VLDR)	25	0.30	0.41	0.49

FIGURE X5 (cont.)

LAND USE VS. EFFECTIVE PERCENT IMPERVIOUS AND RUNOFF COEFFICIENTS FOR THE RATIONAL METHOD

Land Use from Aerial Photography	General Plan Land Use Designation	Effective % Impervious	Runoff Coefficient by Hydrologic Soil Group		
			B	C	D
Residential: 1-2 du/acre (2.5-5 du/ha)	N/A	20	0.26	0.38	0.46
Residential: .5-1 du/acre (1-2.5 du/ha)	Rural Residential (RR)	15	0.22	0.35	0.43
Residential: .2-.5 du/acre (0.5-1 du/ha)	N/A	10	0.18	0.32	0.41
Residential: <.2 du/acre (.05 du/ha)	Agricultural Residential (AR)	5	0.14	0.28	0.38
Open Space, Grassland	N/A	2	0.12	0.26	0.36
Agriculture	N/A	2	0.26	0.41	0.51