CITY OF LATHROP

Department of Public Works

Design & Construction Standards

Section 3 Storm Drainage Standards

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SECTION 3
STORM DRAINAGE STANDARDS

PURPOSE

The storm drainage standards are intended to establish the minimum standards for the design and construction of storm drainage pipes, ditches, berms, channels, detention and retention basins, gutters, curbs, inlets, outlets, outfalls and other storm drainage appurtenances associated with new development projects. All design and construction of new storm drain facilities shall be in accordance with accepted engineering practices, current BMPs (Best Management Practices), and these minimum design standards.

All new developments and significant re-development shall incorporate the requirements of the City's Multi-Agency Post-Construction Stormwater Standards Manual, latest revision. Applicable projects must submit a *Project Stormwater Plan* (PSP) and incorporate into their plan site design measures, source control measures, stormwater treatment control measures, and meet hydromodification requirements, if applicable. A long term Operation and Maintenance (O & M) Plan is required to be submitted with the PSP. The Multi-Agency Post-Construction Stormwater Standards Manual is available on the City's website.

3-2 DEFINITIONS

See Section 1-2 DEFINITIONS.

3-3 STORMWATER TREATMENT AND BEST MANAGEMENT PRACTICES

A. All new development of any size shall incorporate requirements and principles of the City's Multi-Agency Post-Construction Stormwater Standards Manual and the current Phase 2 MS4 NPDES permit.

B. The Manual includes the following requirements for applicable new development and redevelopment projects:

1. Site Design Measures that include soil types and infiltration rates, setbacks, environmentally sensitive areas (ESAs), drainage management areas (DMAs), pollutants of concern (POCs), and low impact development (LID) measures.

2. Source control measures that provide specific standards for a variety of activities and property uses. Fact sheets for each source control measure are installed in Appendix E of the Manual and specify required pollution prevention activities, Best Management

Practices, design considerations, and maintenance requirements to ensure effective implementation of the source control measure.

3. Treatment control measures that infiltrate, bioretain, evaporate / transpire, or capture and reuses storm water. Collectively, these are known as non-structural control measures. Structural treatment control measures may only be used if non-structural is proven to be not feasible per the criteria in the Manual.

4. Hydromodification requirements for projects that create or replace 1 acre of permeable surfaces. It requires that the post-construction stormwater runoff flow rate not exceed the estimated pre-project flow rate for the 2-year, 24-hour design storm event. A project that does not result in a net increase of impervious surface area over the pre-project condition is not considered a Hydromodification Management Project.

5. The submittal of a Project Stormwater Plan (PSP) with supporting drawings and calculations. Certain projects will also require that a Site Conditions report, Operations and Maintenance (O & M) Plan, and hydrologic modeling be submitted. The PSP must be prepared and stamped by a licensed professional engineer or landscapes architect.

3-4 DESIGN STORM, DRAINAGE REPORTS AND IMPROVEMENT PLANS

It is the goal of the City to provide 100-year, 24-hour return frequency and duration flood protection for all habitable structures, consistent with the City Code of Ordinances. However, the City Engineer or the governing body may require flood protection of 200-year return frequency for new development based on a determination of "unreasonable risk" in Government Code 65302.7(b). Consequently, all drainage reports and plans must demonstrate a minimum 100-year flood protection criteria unless enhanced risk avoidance is deemed necessary.

A. A drainage report and grading plan must be submitted for projects larger than two acres. Projects less than two acres will be checked on a case-by-case basis with requirements determined by the City Engineer. Drainage reports shall contain the information required by this section.

B. The storm frequency to be used in drainage system design will be the storm frequency applicable for the design problem under consideration. The following guidelines give a general rule for determining applicable design storm frequency. The actual storm frequency used will be Flood Protection Level (FPL) as explained in the Definitions section.

1. 10-Year, 24-hour Storm:

   a. The drainage system for the 10-year, 24-hour storm is to be designed to minimize inconvenience, protect against minor damage, and reduce maintenance costs.

   b. Improvements to be designed for the 10-year, 24-hour storm shall generally include local drainage facilities for residential, commercial, office and industrial development. This will almost always include all closed conduit design and minor channel sections.

   c. For design purposes, the precipitation depth for a 10-year, 24-hour storm is **2.35 inches**.

2. 100-Year, 24-hour Storm:

   a. The drainage system for the 100-year, 24-hour storm, or as required by the FPL, is to be designed to protect against loss of life or substantial property damage. Improvements requiring the assigned FPL design capacity are open channels, detention and retention basins, minor channels, closed conduit systems and overland releases pathway, where specified in these Standards.

   b. For design purposes, the 100-year, 24-hour storm is considered to be **3.30 inches**.

3. FEMA regulations shall be complied with at all times. However, this does not preclude the City from requiring a higher standard to protect the public from project runoff.

C. All storm drainage facilities shall include provisions for future upstream development. A development shall not discharge at a rate which exceeds the capacity of any portion of the existing downstream system. Calculations for storm drainage design within a development as well as calculations for runoff generated by the upstream areas within the contributing watershed shall be submitted to the City Engineer for approval. These calculations are to be based upon ultimate watershed development and shall include:

1. A hydrology calculation for 10-year and 100-year 24-hour storms, together with assumptions, charts, tables, references and methods used.

2. Topographic map showing existing and proposed elevations that show on-site and off-site watershed boundaries draining onto the

site. It shall also include the relationship between proposed development and the remainder of the watershed, including acreages of all sub-areas. (Preferably @ 1" =100' scale)

3. Calculations of pre-development and post-development design runoff of the entire basin.

4. Maps of the proposed development indicating and supporting calculations for:

    a. All applicable existing and proposed improvements including pipe size, type, class, length and gradient, shown in plan and profile.

    b. Runoff coefficients for all areas where runoff is calculated.

    c. Time of concentration and intensity of rainfall at each hydraulic structure.

    d. The magnitude and direction (indicated by arrows) of flow in each pipe and flow to each structure contributed by its tributary area. All flow rates shall be in cubic feet per second (cfs).

    e. Elevation of pipe inverts at structures and the top of elevation at each structure.

    f. Capacities, depth of flow, and size of proposed gutters, drain inlets and catch basins for each pipe reach. The calculations shall include any bypass flow from upstream inlets.

    g. The overland release path which prevents flooding to existing and proposed structures in the event of malfunction or overloading of the drainage system. The overland release path shall also be designed to carry the FPL flows that exceed the capacity of the drainage system under saturated conditions. The overland release path shall be shown on the drainage plan for the project. All pad grades shall be a minimum of 1-foot above the FPL water surface or 1-foot above the overland release elevation, whichever is higher. Streets, parking lots, playgrounds, pedestrian areas, pedestrian walkways, exclusive of utility easement and other open space areas may be considered compatible with the overland release.

5. Tabulation sheet that includes all of the above information and summarizes the design in a clear, concise, professional format.

6. Construction Plan and Profile drawings shall include:

   a. Water surface elevation called out on profile view at each structure with the hydraulic gradient for the design storm indicated in the profile.

   b. All flow rates in the cubic-foot-per-second (cfs) called out on profile view for each conduit.

D. At intersections of pipes, the downstream pipe shall have a crown elevation, which is equal to the crowns of all upstream connecting pipes unless an alternate means is approved by the City Engineer. Pipe diameters shall not decrease in the downstream direction.

3-5 DESIGN STORM RUNOFF

The methodology to be used shall be as those provided in the Hydrology Manual for San Joaquin County, September 1997 Final Draft.

3-5.1 Rational Method

The Rational Method tends to become impractical in large, more complex watershed areas. Characteristics such as varying travel for multiple watershed branches and watershed storage are not addressed adequately by the Rational Method. Therefore, the Design Engineer is required to use a Hydrograph method for determining runoff when the drainage basin is larger than 200 acres or when a detention basin is to be designed. If the Rational Method is used, the peak flow rate for the design storm shall be determined as follows:

$Q = CIA$

Where...

Q = peak rate of flow in cubic feet per second (cfs).

C = coefficient of runoff having a value between 0.0 and 1.0 depending on surface characteristics.

I = the average intensity of rainfall in inches per hour for a duration equal to the critical time, usually the time of concentration.

A = the tributary area, in acres, corresponding to the critical time above.

The procedures for determining the values of C, I, and A are given in the following subsections:

A. Runoff Coefficient, C: Runoff coefficients shall be calculated by a Registered Civil Engineer and submitted to the City Engineer for approval.

B. Rainfall Intensity, I: Peak runoff for the 10-year storm shall be based on the Mean Annual Precipitation of 13.5" and the Rainfall Intensity – Duration Curve, shown in Appendix K. Runoff for the 100-year storm may be determined by multiplying the 10-year peak rate by 1.4.

C. Tributary Area, A: The tributary area for each point of computation shall be based on actual field reconnaissance or use of appropriately scaled maps that clearly depict the drainage boundaries. All of the area that will contribute runoff to the drainage system shall be considered, regardless of the limits of the particular development under consideration.

D. Critical Flow Time: The critical flow time is the time resulting in the maximum flow rate for a given point in a drainage system. Maximum flow occurs when the product of the contributing area and the rainfall intensity corresponding to the flow time is at a maximum.

1. The time of concentration (Tc) is defined as the interval of time (in minutes) required for the flow at a given point to become a maximum under uniform rainfall intensity. Generally, the time required for water to flow from the most hydraulically remote point in the watershed to the point in question is the time of concentration. Using the intensity corresponding to this time and the entire drainage area in the Rational Method usually results in the maximum flow rate for the point.

2. The monograph shown in Appendix K shall be used to determine the time of concentration to the first inlet of the drainage system. The minimum inlet time is 10 minutes, regardless of land use.

3. When any part of the storm waters is conveyed to the point in question by pipes or open channels, the flow time in these conveyances shall be added to the inlet time to compute the total flow time. In complex drainage situations, more than one computation may be required in order to determine the computation of contributing area and flow time that results in the maximum flow rate.

3-5.2 **Hydrograph Methods**

Hydrograph methods of analysis are required for the larger, more complex watersheds. A hydrograph method is also required for the modeling of a proposed detention basin. The following is a summary of the hydrologic models available to the Design Engineer and acceptable by the City for the modeling of existing and proposed watershed areas. The use of other programs may require additional information verifying the validity of the program used.

A. The methodology described by the County of San Joaquin Hydrology Manual, September 1997, Final Draft is an acceptable technique.

B. Technical Release No. 20 (TR-20):

1. The Soil Conservation Service (SCS) originally developed the TR-20 hydrologic model. The model develops flood hydrographs and routes the flow through stream channels and reservoirs. It is capable of combining hydrographs and determining peak discharges, time of occurrence and water surface elevations. The model is based on the procedures described in the National Engineering Handbook, Section 4, Hydrology (NEE-4)

2. The TR-20 computer program and hydrologic model is to be based on the statistical design storm required by these Standards with rainfall distribution and total precipitation as designed and recommended by the U.S. Soil Conservation Service. The model is to be based upon the Standard Methodologies set forth in the most recent version of the SCS Technical Release No. 20 and Section 4 of the National Engineering Hydrology Handbook.

C. Technical Release No. 55 (TR-55):

1. Technical Release No. 55 (TR-55) uses a derivation of the TR-20 hydrograph methods to develop flood hydrographs. As a simplified version of the TR-20 model, it allows the designer to evaluate a watershed and develop comparable results without using the more complex model.

2. The input variables required with TR-55 include Curve Number (CN), Time of Concentration (Tc) and drainage area. The model is based on a 24-hour statistical design event. The total rainfall volume and appropriate rainfall distribution for the design storm is to be derived in accordance with the recommendations of the U.S. Soil Conservation Service. The watershed model is to be based on the most recent revision of TR-55 and its standard methodologies.

3. The TR-55 hydrologic model only provides runoff hydrographs and does not include a computer program for routing hydrographs through detention basins. If the TR-55 model is used for a proposed detention basin, an additional program will be required for hydrologic routing. The Storage Indication Method or Modified Pulse Method is an acceptable model for the sizing of detention basins.

D. U.S. Army Corps of Engineers HEC-1:

1. The U.S. Army Corps of Engineers Hydrologic Engineering Center developed the hydrology program HEC-1. The model is capable of analyzing flood events for a wide range of conditions, from small urban watersheds to large, multiple watershed river basins. The basic components of the model include the development of surface runoff for each watershed, channel and reservoir routing and the combining of hydrographs at confluences. The model also contains numerous program options such as Dam Break Analysis, Flood Damage modeling and many others, which in general only pertain to large-scale capital improvements. It is recommended that the soil conservation service methodology to be used in conjunction with the HEC-1 model.

2. The HEC-1 computer model is to be based on the statistical design storm required by these Standards and the Standard Methodologies set forth in the most recent version of the U.S. Army Corps of Engineers HEC-1 hydrologic computer model.

3-5.3 **Run-on Flows**

Flows entering the proposed development from outside the property are run-on flows. The run-on must be determined and included in the drainage system design. Available drainage reports for off-site developed areas affecting the property must be reviewed and considered in the drainage system planning and design. Run-on entering the site from off-site areas must be computed using parameters for the existing development or based on General Plan Zoning, whichever is greater.

3-5.4 **Drainage Diversion**

The diversion of natural drainage will be allowed only within the limits of the proposed improvement. All natural drainage must enter and leave the improved area at its original horizontal and vertical alignment unless an agreement, approved by the City Engineer, has been executed with the adjoining property owners.

A. Temporary drainage diversions, such as dams and pipe plugs, shall be located and constructed in such a fashion as to permit their removal during adverse weather.

B. The City Engineer shall approve locations and removal procedures for temporary drainage installations, and these installations shall be removed when necessary to prevent damage to adjoining property.

3-5.5 High Ground Water Table

There are areas within the City with high ground water. These areas may require special design features such as trench drains to be incorporated into the project design for storm drainage facilities, street structural sections, detention and retention basins to eliminate the following problems:

A. Premature failure of trenched street sections due to saturated sub-grade.

B. Seepage around building foundations.

C. Infiltration of ground water into storm drain and sanitary sewer lines.

D. Seepage into detention and retention basins or levee areas.

The soils report must indicate the highest historical groundwater elevation in the project area or provide the design high groundwater elevation based on review of available information.

3-6 HYDRAULIC CRITERIA

3-6.1 Manning Equation

The Manning Equation shall be used to determine the capacity of open channels and enclosed gravity conduits:

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

Where…

Q	=	Flow rate in cubic feet per second
A	=	Cross sectional area of the flow in square feet
V	=	Flow velocity in feet per second
R	=	Hydraulic radius in feet
S	=	Slope in feet per foot
n	=	Manning coefficient of roughness

Values of the Manning coefficient for various pipes and open channels are given in Table 3-1.

TABLE 3-1

MANNING COEFFICIENT

CONDUIT MATERIAL	MANNING COEFFICIENT
Closed conduits	
Cast iron pipe	.013
Concrete pipe	.013
Corrugated metal pipe, plain	.024
Paved invert	.020
Fully paved	.015
Plastic	.013
Vitrified clay pipe	.013
High Density Polyethylene Pipe	.012
Open Channels	
Lined Channels	
Vegetated	.040
Asphalt	.018
Concrete	.015
Rubble or riprap	.030
Excavated or dredged	
Earth, straight & uniform	.030
Earth, winding, fairly uniform	.040
Un-maintained	.100
Natural channels (minor streams)	
Fairly regular sections	.050
Irregular section with pools	.100

Adapted from Table XIV, ASCE Manual No. 37, 1970

3-6.2 Pipe Flow Criteria

A. For ease of maintenance, all catch basin laterals shall be not less than 15 inches in diameter. All mains or trunk lines shall not be less than 15 inches in diameter. Minimum allowable pipe size for private storm drain lines connecting to the public system is 12 inches in diameter.

B. The minimum velocity in closed conduits shall be 2 fps when flowing eight-tenths full. The maximum velocity shall not exceed 20 fps.

C. The hydraulic grade line (HGL) of the FPL design storm must be computed for all storm drain systems. The HGL for the 10-year frequency storm must be shown on the design profile when it is above the top of the pipe. The HGL for the 10-year frequency storm shall be a minimum of 1.0 foot below the elevation of the inlet grates and manhole covers of all structures within the system and shall be within the street right-of-way for the FPL frequency storm.

3-6.3 **Open Channel Flow**

A. Maximum velocities in open channels shall be as follows on Table 3-2.

Table 3-2

OPEN CHANNEL MAXIMUM VELOCITY

CHANNEL MATERIALS	MAXIMUM ALLOWABLE VELOCITY (fps)
Fine sand	2.0
Sandy loam	2.5
Alluvial silt	3.0
Firm loam	3.5
Firm gravel	4.0
Stiff gravel	4.5
Coarse gravel	5.0
Bottom paved channels	8.0
Fully concrete lined channels	10.0

B. Freeboard must be a minimum of 1 foot measured from the top of channel to the HGL.

C. At the City Engineers discretion, flows shall be placed in closed conduits where the flow requires a concrete pipe of less than 66-inch diameter.

D. Water surface profiles are to be computed for both existing and ultimate conditions. Hydraulic grade lines (HGL) shall be indicated on the profile view of the construction plans prior to plan approval. A copy of the HGL calculation or other hydraulic model on a disk and printout verifying HGL shall be submitted to the City Engineer. Unless otherwise approved by the City Engineer, all hydraulic grade line calculations shall begin at the ultimate FPL channel water surface elevation.

3-6.4 Backwater Effects

A. When obstructions, transitions, junctions, constrictions or other irregularities in an otherwise uniform channel system create backwater conditions in the system, the Design Engineer shall make computations to determine the effects of the backwater condition.

B. The Design Engineer shall use careful consideration in determining when losses due to channel irregularities are small enough to ignore or when they are large enough to create considerable backwater effects. Such considerations shall be noted on calculations.

3-6.5 Inlet Criteria

Drain inlets shall be constructed per Standard Details D-2, D-4, D-5, D-6 and D-7. The standard curb inlet shall be "Type I" inlet as specified in Drawings D-4. Use of "Santa Rosa" style grate-less inlets requires approval by the City Engineer.

Requirements for inlets are as follows:

A. Inlets shall be placed so that the length of flow in the gutter does not exceed 500-feet in either direction. The flow rate used to check the depth shall include any runoff that may by-pass upstream grates. Exceptions to the 500-feet limit standard may be granted by the City Engineer.

B. A clogging factor of fifty percent (50%) shall be used when computing the interception capacity of the inlet.

C. The connector pipe from inlets at sag points shall be sized to accommodate the design runoff taking into consideration bypass flow from upstream inlets.

D. Caltrans type OCP or OCPI, Sheet D75B, inlets shall be used in unimproved medians, and may be used in roadside ditches away from driveway locations and in back lot situations.

E. Curb opening catch basins with grating(s) and debris skimmer, Caltrans type GO, Sheet D74B, shall be used in locations where additional inlet capacity beyond what a single "Type I" inlet can intercept. If further grate capacity is required then Caltrans type GT4, Sheet D74A, may be considered.

F. Inlets in streets shall be placed at lot lines in residential subdivisions, except at intersections where they shall be placed at the curb return. **Inlets shall not be allowed within street crosswalks or any driveways.**

G. A minimum horizontal distance of eight feet (8') along the trunk line must separate laterals.

H. Frames and Gates to be specified for pedestrian or Traffic Loading. All grates to be bicycle proof, have a grate locking device, be closed-mesh grates or cast iron frame and grates available for approval form the City Engineer.

I. Floor slope to be determined in the field by the City of Lathrop Inspector.

J. Top edge of structure to be straight or chamfered per approval from the City Engineer.

K. For all turf areas that would require larger heavier maintenance equipment such as mowers, fertilizers and herbicide applications, etc.

L. Source is Oldcastle Precast Inc., or approved equal.

3-6.6 Surface Flow and Allowable Inundation

A. In all cases, the hydraulic grade lines (HGL) for a FPL design storm shall be one foot below the lowest floor of adjacent structures.

B. The depth of flow for a FPL design storm shall not extend beyond the street right-of-way and maintain at least a minimum 10-foot wide drivable paved area on major streets for public safety purposes. Also, in the event of pump station failure during a FPL storm, dry access to the pump station needs to be provided.

3-7 DRAINAGE STRUCTURES

3-7.1 Alignment of Drainage Facilities

A. Drainage pipelines shall be located in the street whenever possible. The locations shall be in accordance with Standard Detail No. R-63. Alternate locations using Standard Details R-64 and R-65 shall require approval of the City Engineer.

B. Drainage pipelines shall be aligned straight between structures except where parallel to the street centerline per paragraph A above. Long radius curves are permitted for pipe 24 inches and larger. The radius of curvature shall not be less than 100 feet or 80% of the manufacturer's recommendation for curved alignment, whichever is greater. Curves, radii, and length of pipe joints must be shown on the improvement plans.

3-7.2 Easements

A. Permanent easements shall be provided for drainage facilities not located in the public right of way. Drainage facilities within easements shall conform to the requirements in Section 4-5.3 Easements.

B. Open Channels: Easements for open channels shall have sufficient width to contain the open channel with side slopes, fencing where required, and 15-foot service road when required by the City Engineer. Suitable ramps must be provided for access to the bottom of the channel if the bottom requires maintenance. Open channels shall only be used with prior approval of the City Engineer.

3-7.3 Closed Conduit Design

A. All closed conduits shall be minimum Class III to V reinforced concrete pipe providing watertight connections. ADS HP Polypropylene Pipe (or approved equal) is approved for up to 60" diameter, greater than 60" diameter requires the approval of the City Engineer. Alternative pipes may be used only with the approval of the City Engineer.

B. The specified type of pipe or alternate pipes shall be shown on the plans. If the use of alternative pipe(s) are desired and are not shown on the plans, revised plans must be submitted to the City Engineer for approval.

C. Pipe bedding, backfill and cover requirements are shown on Standard Details No. R-52 through R-56. If the minimum cover requirement cannot be provided, the conduit shall be encased in Class B concrete to provide a protective cover and support. Other methods for protecting and supporting the pipe may be used only with the approval of the City Engineer.

D. When different size pipes meet at a junction, the pipe crown elevations shall be matched unless otherwise approved by the City Engineer.

E. When the groundwater is at or above the bottom of the pipe, the design shall comply with City Standard R-57.

F. All closed conduits shall be cleaned and inspected by closed circuit television system. The means and methods for this work is provided in Appendix J. The inspection shall be provided to the City for review prior to final approval.

3-7.4 Manholes and Junction Boxes

A. Standard precast concrete or saddle type manholes per Standard Detail Nos. D-8, D-9, and D-10 shall be used where feasible. For cases where special manholes or junction boxes are necessary, the design must be detailed on the drawings and approved by the City Engineer. In no case shall manholes or junction boxes be allowed which are smaller than 24 inches inside dimensions. All manholes and junction boxes other than inlets shall have standard manhole covers. Slotted manhole covers may be used when approved by the City Engineer to pick up minor drainage in non-traffic areas. These covers will not be allowed in gutters.

B. Manhole shall be constructed at junction points, angle points greater than 15 degrees, changes in grade and changes in pipe size. On curved pipes, manholes must be located at both the B.C. and E.C. of the curve.

C. All mating surfaces of rings and joints shall be sealed with "RamNek" or gasket applied prior to placing rings, and exterior shall be sealed with "Rubr-Nek" installed on all joints.

D. Maximum spacing of manholes shall be as allowed:

1. For pipe sizes 24 inches or less in diameter, the maximum spacing of manholes shall be 400 feet.
2. For pipes greater than 24 inches in diameter, the maximum spacing may be up to 600 feet.
3. For curved pipe with radii less than 400 feet, maximum spacing shall be 300 feet.
4. For curved pipe of radii 400 feet or greater, the maximum spacing shall be 400 feet for pipe 24" or less in diameter and 500 feet for pipe greater than 24" in diameter.

E. Manholes shall be sized as follows:

1. Drain inlets may be used in lieu of manholes where the upstream pipe terminates in a drain inlet, and is no more than 15 inches in diameter and 50 feet long and the downstream pipe terminates in a manhole and is no more than 15 inches in diameter.
2. A 48-inch pre-cast manhole, Standard Detail D-8, shall be used for pipes up to a maximum inside diameter of 36 inches. The manhole shall have no more than 24 inches opening for connecting pipes at the same level in any one-manhole quadrant. There shall be a minimum of 5 inches at the inside face of the manhole between the outside of connecting pipes.
3. A 60-inch pre-cast manhole shall be used for pipes up to a maximum

inside diameter of 48 inches. The manhole shall have no more than 36 inches of opening for connecting pipes at the same level in any one-manhole quadrant. There shall be a minimum of 6 inches at the inside face of the manhole between the outside of connecting pipes.

4. A 72-inch pre-cast manhole shall be used for pipes up to a maximum inside diameter of 60 inches. The manhole shall have no more than 48 inches of opening for connecting pipes at the same level in any one-manhole quadrant. These shall be a minimum of 6 inches at the inside face of the manhole between the outside of connecting pipes.

5. A 48-inch saddle manhole may be used on pipes 24 inches in diameter or greater with approved submittal from City.

3-7.5 Open Channels

A. Natural Channels: Natural or grass-lined channels shall have a maximum side slope of 3H:1V. For locations of unstable soils, the maximum side slope shall be at the discretion of the City Engineer or the Soils Engineer's recommendation. The minimum bottom width shall be six feet with no shrubs or trees within the flow limits of the channel.

B. Concrete Lined Channels: Concrete lined channels may be constructed if one or more of the following conditions are met:

1. The capacity of pipe less and 66-inch in diameter is exceeded;

2. Where the cover requirements for buried pipe cannot be met;

3. Where the required pipe or natural channel grade cannot be maintained; or

4. Where slope lining is required to maintain the desired channel side slope.

C. Rock Lined Channel: Rock lined channels, including gabions, may be constructed in lieu of concrete channels, but must maintain a maximum of 2H:1V side slopes and conform to the Standard Specifications.

D. Inlet and Outlet Structures:

1. Inlets from channels to pipes shall be designed per Standard Details D-11 and D-12. A trash rack will be required in instances where the City Engineer deems that significant amounts of debris may occur at the inlet. Trash racks shall be designed per Standard Detail D-11 and D-13.

2. Outlets from pipes to natural or grass-lined channels shall include erosion control provisions per Standard Detail D-14.

E. Improved channels where the maximum design depth is 18 inches or more and with side slopes 4H:1V or steeper shall be fenced with a six (6) foot high chain link fence constructed per Standard Detail D-18, or where applicable as required by the UDC. The fence shall be located 6 inches within the required drainage area/easement lines. An eighteen (18) foot double gate shall provide access to the fenced area.

3-7.6 **Detention and Retention Systems**

A. Detention basins and retention ponds shall be constructed per Standard Detail D-17. The City Engineer must approve any deviation from this design in writing. The maximum side slope for privately maintained detention basins or retention ponds shall be four horizontal to one vertical (4H:1V) unless otherwise recommended by a Registered Soils Engineer or Engineering Geologist licensed in the State of California. These slopes may be steeper than the four to one (4:1) as long as the soils report supports and recommends the steeper slope. Retention and detention basins accepted for maintenance by the City shall have no side slopes greater than four to one (4:1). Detention basins or retention ponds landscaped with turf that requires mowing shall have a maximum side slope of six horizontal to one vertical (6:1).

B. Detention basins and retention ponds in developed areas where the maximum design depth is 18 inches or more with side slopes 4:1 or steeper shall be fenced with an eight (8) foot high chain link fence constructed per Standard Detail D-18, or where applicable as required by the UDC. The fence shall be located 6 inches inside the drainage area/easement lines. A minimum twelve (12) foot signal gate shall provide access to the fenced area. Additional fence and gate design features may be required by City Engineer.

C. A minimum 12-foot wide access road to the basin or pond bottom is required for maintenance vehicles if the side slope exceeds four to one (4:1). For small private developments (total basin area less than one acre), a three (3) foot set-back of the fence from the top-of-slope of the basin is acceptable. For large developments (total basin area greater or equal to one acre), a perimeter access way shall be located around the basin or pond with a fifteen (15) foot minimum inside turn radius at the corners. All access ways shall be located within any required fencing.

3-7.7 **Detention Basins**

Detention basins shall be incorporated with other public uses whenever possible.

A. Detention basins other than those shown on the Storm Drainage Master Plan may be used on an interim basis pending completion of the Master Plan facility or for staged development only with approval of the City Engineer. Where possible, "free form" should be incorporated into the design.

B. All detention basin design volumes shall be computed based on the FPL storm. The contributing watershed area shall be evaluated using standard engineering methodologies detailed in Section 3-5.1, Rational Method. The total volume required for the basin shall be based on hydrologic routing computations detailed in Section 3-5.2, Hydrograph Methods, to be provided by the design engineer demonstrating that the basin will operate properly.

If the hydrologic routing computations are not provided, the volume required for the basin shall be given by the equation (to be calculated by a Registered Civil Engineer and submitted to the City Engineer for approval):

$$V_p = \frac{CAR}{12}$$

Where …

V_p = the volume of detention pond required in acre-feet.

C = the runoff coefficient.

A = the contributing area in acres.

R = 10-year, 24-hour rainfall at 2.35 inches, the 100-year, 24-hour storm at 3.30 inches

C. All detention basins shall have outlet facilities providing terminal drainage capable of emptying a full basin within 96 hours.

1. Detention basins with gravity outlet structures will operate without backwater effects under the design storm.

2. A drainage pump may be designed as the basin outlet control. A backup power generator will be required to accompany any drainage pump.

D. The bottom of the basin shall be a minimum of 5 feet above the design high groundwater elevation as recommended in the soils report pursuant to the 2015 Multi-Agency Post-Construction Stormwater Standards Manual, and shall meet all requirements of the State Regional Water Quality Control

Board (RWQCB). It is the responsibility of the developer's Design Engineer to coordinate with the RWQCB and submit evidence of their approval to the City Engineer.

E. A minimum 12" freeboard or 25% over-sizing, whichever is less, shall be required.

F. Detention basins shall be designed with gravity inflow and gravity outflow whenever possible. (i.e., large pipe in/smaller pipe out, or overflow in/clap-gated outlet). Detention systems requiring pumping facilities must meet the requirements of Appendix H, Wastewater and Storm Water Pump Station Criteria, of these standards and must be approved by the City Engineer.

G. The bottom of a detention basin shall be sloped at a minimum of 1% towards the outlet works. Whenever possible, a low flow channel or pipe through the basin shall be incorporated into the design.

H. In accordance with City requirements, landscape design with secondary use facilities shall be included as part of each design system.

3-7.8 Retention Basins

Development will be required to provide terminal drainage where developments are within a reasonable distance of a terminal drainage facility as determined by the City Engineer. When this condition is not available, retention basins utilizing percolation as a means for emptying the basin may be used only with the approval of the City Engineer.

A. Retention ponds shall conform to the following design criteria:

1. A project specific soils report evaluating the subsurface soil and groundwater conditions for the retention basin shall be prepared by a qualified Soils Engineer or Engineering Geologist licensed in the State of California. The report shall provide the design high groundwater elevation with justification and substantiating groundwater monitoring data.

2. The bottom of the basin shall be a minimum of 5 feet above the design high groundwater elevation as recommended in the soils report pursuant to the 2015 Multi-Agency Post-Construction Stormwater Standards Manual, and shall meet all requirements of the State Regional Water Quality Control Board (RWQCB). It is the responsibility of the developer's Design Engineer to coordinate with the RWQCB and submit evidence of their approval to the City Engineer.

3. Percolation test results must be provided, with calculations indicating that the retention basin is designed to empty one hundred (100%) percent of the required volume of storage within ten (10) calendar days. Percolation shall be constrained to bottom only.

4. The retention pond design shall be the responsibility of the Design Engineer, and subject to review and approval of the City Engineer.

5. Permeability and differential head available must be considered for the life of the project, not just present values.

6. The volume of storage required shall be two hundred (200) percent of the computed volume of water to be stored. The volume of retention pond storage is:

$$V_p = \frac{2.0\ (CAR)}{12}$$

Where …

V_p = the volume of retention pond storage required (acre-feet).

C = the runoff coefficient (to be calculated by a Registered Civil Engineer and submitted to the City Engineer for approval).

A = the contributing area in acres.

R = the total rainfall, in inches for the 100-year, 24-hour storm. (Use R=**3.30 inches**)

7. Levees or berms shall not be permitted around retention basins. The top of pond, for calculation purposes, shall be at least 1.0 feet below the lowest top of curb or street centerline in tributary area.

3-7.9 **Pump Station**

Pump stations shall conform to the requirements in Appendix H for the design of storm water pump stations

END OF SECTION