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PART III - MINIMUM DESIGN STANDARDS

SECTION 105.

STORM DRAINS AND IRRIGATION

105.1. STORM DRAINS

All design and analysis of storm drainage systems in the City of Arvada shall be done in accordance with the following specifications.

105.2. METHODS OF ANALYSIS

All analyses must be in conformance with Urban Drainage and Flood Control District Vol. 1, 2, & 3, Latest Edition (The Manual). Two acceptable methods of flow analysis are the Rational Method and the Colorado Urban Hydrograph Procedure (CUHP).

105.2.1. Rational Method

Flows may be determined by the extended form of the rational formula:

- A. Rainfall intensities shall be taken from Table 105.2.
- B. Concentration times for flow analysis should never be less than ten (10) minutes.

105.2.2. Colorado Urban Hydrograph Method

Flows may be calculated by the Colorado Urban Hydrograph Procedure. When this method is used the rearrange incremental precipitation shall be taken from Table 105.2.

- A. Infiltration rates for pervious area should be one-half (1/2) inch per hour through the entire 100-year storm. The first 1/2 hour of the 3.5-year storm can have an infiltration rate of one (1) inch per hour. For the remainder of the storm the rate shall be one-half (1/2) inch per hour.
- B. Depression detention should be taken from The Manual.
- C. Perviousness of undeveloped land shall be taken as 95 percent.

105.2.3. Facility Capacity Criteria

All drainage facilities must be approved by the City Engineer.

- A. Curb flow capacity is reached when the flow crosses the back of the curb or the crown of the street is reached, whichever is less.
- B. Transfer of water from one flow line to another, by flow over the crown, will not be allowed.

- C. Storm sewer shall be designed to carry the 3.5 year runoff.
- D. Minimum size for storm drainage pipe shall be fifteen (15) inches.
- E. Pipe under streets shall be designed for soil and live loads in accordance with acceptable highway design criteria. The D-Load method is an acceptable method of design.
- F. Collector streets shall be drained so that the center twelve (12) feet are clear of water during the 3.5-year storm.
- G. Parkways shall be drained so that the center 24 feet are clear of water during the 100-year storm.
- H. Local streets shall have the catch basins at the point where either side of the street reaches its capacity for the 3.5-year frequency storm.
- I. Catch Basin Capacity in cubic feet per second: Shall be calculated in accordance with the methods outlined in The Manual, Volume 1.
- J. Culverts under streets (excepting major arterials) shall be designed with an emergency overflow for passing the 100-year storm. In determining the required capacity of the overflow, the culvert shall be assumed blocked unless its cross-sectional area exceeds twenty (20) square feet, in which case 60% of its flow capacity may be used.
- K. Major channels shall be designed to safely pass the 100-year storm. Design and improvements shall be made in accordance with the recommendations of The Manual.
- L. Velocities in any conduit or channel shall be controlled so that the conduit or channel will not be damaged by flows from the 100-year flood, unless otherwise instructed by the City Engineer.
- M. Suggested values of Manning's "n" appear in Table 105.1 below.

TABLE 105.1

Roughness Coefficient

Character of Section	Mannings 'n'
Polyvinyl Chloride Pipe	0.011
Concrete Pipe	0.013
Corrugated Metal: 2 2/3" x 1/2" Corrugation	0.024
3" x 1" Corrugations	0.027
Structural Plate: 6" x 2" Corrugations	0.033
Open Channels: Undisturbed	0.035
Earth Reshaped	0.020
Grassed and Shaped	0.030
Concrete Lines	0.013
Rip Rap Lined	0.035

TABLE 105.2
Rainfall Intensities

Time	100 – YEAR			3.5 - YEAR		
	Maximum Precipitation	Rearranged Incremental Precipitation	Average Intensity	Maximum Precipitation Depth	Rearranged Precipitation Depth	Average Intensity
10	1.14	0.04	6.84	0.64	0.02	3.84
20	1.51	0.06	4.53	0.87	0.03	2.61
30	1.82	0.08	3.64	1.02	0.05	2.04
40	2.00	0.13	3.00	1.11	0.08	1.67
50	2.13	0.37	2.56	1.19	0.15	1.43
60	2.25	1.14	2.25	1.26	0.64	1.26
70	2.34	0.31	2.01	1.31	0.23	1.12
80	2.42	0.18	1.82	1.36	0.09	1.02
90	2.50	0.12	1.67	1.40	0.07	0.93
100	2.57	0.09	1.54	1.43	0.05	0.86
110	2.63	0.08	1.43	1.46	0.04	0.80
120	2.69	0.07	1.35	1.49	0.03	0.75
130	2.74	0.06	1.26	1.52	0.03	0.70
140	2.79	0.05	1.20	1.55	0.03	0.66
150	2.84	0.05	1.14	1.58	0.03	0.63
160	2.89	0.05	1.08	1.61	0.03	0.60
170	2.93	0.05	1.03	1.63	0.03	0.58
180	2.97	0.04	0.99	1.65	0.02	0.55

105.2.4. Runoff Detention

The City of Arvada Land Development Code requires that additional runoff caused by development be detained on the development site.

105.2.5. Detention Volume

Detention volumes shall be determined in accordance with The Manual.

105.2.6. Detention Time

No specific detention time is required under normal conditions. However, if the City Engineer determines that a longer detention time is in the City's best interest, he may require a flow rate less than half the historic peak flow rate ($Q_H/2$) before two (2) times the historic concentration time ($2T_c$) is reached.

105.2.7. Allowable Release Rate

Allowable release rate shall be calculated as determined by The Manual, however, the maximum release rate from the detention facility shall not exceed the historical peak runoff rate for the same frequency storm.

When it is in the City's best interest to alter this release rate, the City Engineer may request a specific release rate.

105.2.8. Detention Structures

The type and design of the detention structure must be approved by the City Engineer.

Generally acceptable examples of detention facilities are ponds or buried pipe.

Overflow structures shall be provided where the design capacity of the detention structure can be exceeded. This overflow structure shall return the overflow water to the historic channel without causing damage to either the detention or overflow structures.

105.2.9. Detention Pond Slopes

Side slope on detention ponds shall be a maximum of 4:1. Bottom of pond shall be a minimum of 2% across landscaped areas.

105.2.10. Flood Hazard Exposure

Developers shall design and accomplish final grading in such a manner that buildings and basement openings will be at or above an elevation that will prevent adverse effect from storm water due to a 100-year return frequency storm.

105.2.11 Policy of Adequate Drainage

- A. Adequate drainage of surface waters means the effective conveyance of storm and other surface waters through and from the development site and the discharge of such waters into a natural watercourse, i.e., a stream with incised channel (bed and banks), or pipe capacity analysis required through two downstream manholes without adverse impact upon the land over which the waters are conveyed or upon the watercourse or facility into which such waters are discharged.
- B. Include sufficient easement extensions to property lines to permit future development reasonable access to drainageways or drainage facilities for connections.
- C. The drainage system shall be designed:
 - 1. To convey such waters to a natural watercourse, i.e., a natural watercourse at the natural elevation, or an existing storm drainage facility.
 - 2. To discharge the surface waters into a natural watercourse at the natural elevation, or into an existing facility of adequate capacity.
- D. The drainage system shall be designed such that properties including public right-of-ways, over which the surface waters are conveyed, from the development site to discharge point(s), are not adversely affected.
- E. Concentrated surface waters shall not be discharged on adjoining property, unless an easement expressly authorized such discharge has been granted by the owner of the affected land or unless the discharge is into a natural watercourse, or other appropriate discharge point as set forth above.
- F. The owner or developer may continue to discharge storm water which has not been concentrated into a lower lying property.
- G. If the discharge conditions are not met and the discharge may aggravate an existing drainage problem or cause a drainage problem, the developer must provide a drainage system satisfactory to the Engineer, to preclude an adverse impact upon

the adjacent or downstream property.

- H. Where open streams are involved, the designer must assess the stream adequacy to receive the two-year run-off without causing erosion or over-bank flooding.
- I. The downstream extent of this review shall be to the point at which an adequate channel is found.

105.3. WATER QUALITY ENHANCEMENT

Water quality enhancement of stormwater runoff must be provided in accordance with The Manual Vol. 3, latest edition.

105.4 IRRIGATION

Required ditch flow shall be determined by existing water rights flowing across and below the design point and certificate of water rights flowing across and below the property shall be submitted to the City Engineer. Alternatively, the ditch pipe and/or structures shall be designed to carry a consistent flow of water as existing ditch is capable. Unless otherwise approved by the City Engineer, all irrigation ditches must be piped.

All irrigation ditch piping must be approved, signed and dated by the President or other authorized officer of the ditch company, prior to approval by the City Engineer.