City of Peoria

2007 WASTEWATER MASTER PLAN

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COLLECTION SYSTEM PERFORMANCE CRITERIA

This chapter describes the "standards of measurement" that were used to evaluate the performance of the existing wastewater system, as well as define the capacity requirements of future improvements. The capacities of gravity sewers, force mains, and lift stations were based on these performance and design criteria. These performance criteria are based upon the Arizona Administrative Code (A.A.C.), City design standards, and common engineering practices. This information was previously presented to the City in a technical memorandum, which is provided in full in Appendix C.

5.1 PIPE CAPACITIES

Sewer capacities are dependent on many factors. These include roughness of pipe, maximum allowable depth of flow, and limiting velocity and slope. The Continuity Equation and Manning's Equation are used for steady-flow hydraulic calculations. The Manning's Coefficient 'n' is a friction coefficient that varies with respect to pipe material, size of pipe, depth of flow, smoothness of joints, root intrusion, and other factors. For gravity sewers, the Manning's coefficient ranges between 0.011 and 0.017. For planning purposes, an 'n' value of 0.013 was used for this project, except where modified during calibration. It should also be noted that ADEQ, through R18-9-E301-D, requires the use of 0.013 for the design of all new construction.

5.2 MINIMUM SLOPES

In order to minimize the settlement of solids in the flow and promote scour, it is standard design practice to specify that a minimum velocity of 2 feet per second (fps) be maintained when the pipe is flowing half full. At this velocity, the sewer flow will typically provide self-cleaning for the pipe. Due to the hydraulics of a circular pipe, the velocity for half pipe flow approaches the velocity of nearly full pipe flow. Table 5.1 lists the minimum slopes for maintaining self-cleaning velocities with d/D = 0.5 or 1.0. The minimum slope listed in the table is 0.0008 ft/ft, which is the minimum practical slope for gravity sewer construction. Greater slopes are desirable if they are compatible with existing topography.

ADEQ regulations require velocities not exceeding 10 fps in gravity sewer mains. However, Peoria's 1995 and 2002 Wastewater Master Plans limited the maximum velocity to 8 fps in gravity sewers to address odors by limiting potential for turbulent flow conditions. For the purposes of this 2007 Wastewater Master Plan, a maximum velocity of 8 fps will also be used.

Table 5.1 Recommended Minimum Slopes for Circular Pipes City of Peoria, 2007 Wastewater Master Plan			
Pipe Size (inches)	**Minimum Slope[(1) (2)] (ft/ft)**	**Pipe Capacity[(3)]**	
		(mgd)	**(cfs)**
8	0.0050	0.45	0.70
10	0.0025	0.70	1.09
12	0.0020	1.02	1.57
14	0.0016	1.38	2.14
15	0.0015	1.59	2.45
16	0.0014	1.80	2.79
18	0.0012	2.28	3.53
20	0.0010	2.82	4.36
21	0.0010	3.11	4.81
24	0.0008	4.06	6.28

Note:

(1) Slopes are calculated using Manning's Equation for full pipe flow with a minimum velocity of 2 fps for all diameters except for 8 inches for which the minimum slope corresponds to 2.5 fps.

(2) Sewers larger than 24 inches should have a slope $\geq$ 0.0008.

(3) Pipe Capacity based on full pipe flow.

5.3 CHANGES IN PIPE SIZE

When a smaller sewer joins a larger sewer, the invert of the larger sewer will be lowered sufficiently to maintain the same energy gradient. An approximate method for securing these results is to place the 0.8 depth point of both sewers at the same elevation. Since Geographic Information System (GIS) data is available for the City's wastewater system, this information will be used for the sewer inverts when available. For master planning purposes, proposed sewer crowns will be matched at manholes when a smaller sewer joins a larger one.

5.4 MANHOLES

It is recommended that manholes be placed according to the maximum allowable manhole spacings shown in Table 5.2.

Table 5.2 Recommended Maximum Manhole Spacings City of Peoria, 2007 Wastewater Master Plan	
Sewer Pipe Diameter (inches)	**Maximum Manhole Spacing (feet)**
10" and less	400
12" and larger	500

5.5 LIFT STATIONS

A firm pumping capacity equal to the peak daily flow is often used to determine the size of lift stations. The lift station should be able to provide a "firm" pumping capacity with the largest pump out of service.

5.5.1 Normal Operation

Lift station wet well sizing takes into consideration the fill time, based on average flow, and the minimum pump cycle time. The Arizona Administrative Code (R18-9-E301-D) requires that the minimum wet well volume in gallons be 1/4 of the product of the minimum pump cycle time, in minutes, and the total pump capacity, in gallons per minute. The volume of the wet well should provide a retention period not to exceed 30 minutes of average daily design flow. In addition, regional lift stations should be provided with additional wet well capacity for redundancy. When selecting the minimum cycle time, the pump manufacturer's duty cycle recommendations shall be utilized. Starting and stopping more than seven times an hour for any one pump is not recommended.

5.5.2 Emergency Operation

The objective of emergency operation is to protect public health by preventing sewer back-ups and subsequent discharge into streets and other public or private property. The most common emergency would be a power outage. All City lift stations are equipped with standby generators to provide a backup power supply. In addition, all City lift stations are tied into the City's SCADA system to relay power fail and high level alarms to on-duty operators.

Specific wet well sizing and back-up power requirements should be based on individual station location, response time, capacities, and severity of impacts from any sanitary sewer overflow.

5.6 FORCE MAINS

Force mains should be sized for normal operating velocities between 3 and 7 fps to provide scour velocity so that the solids deposited while the pumps are off will be transported when the pumps are operating. Pipe retention times should also be considered in sizing force mains and low-pressure systems (LPS) to avoid excessive sulfide generation.

Manholes to which force main(s) or LPS discharge should be constructed with sewer shield coating to prevent attack of concrete by sulfates. Force mains should be dropped into manholes to prevent raw sewage from splashing against the manhole walls and releasing odors. Odor control of discharges from force mains and LPS may be required if they are located in close proximity to homes/businesses or in areas of frequent odor complaints.

5.7 GRAVITY SEWER PLANNING GUIDELINES

Gravity sewers should be designed and constructed to have a minimum 4 feet of cover or sufficient depth to serve the ultimate drainage area.

Gravity sewers should be designed and constructed with a minimum 4 feet of separation between the flowline of drainage ditches and the crown of the sewer.

Gravity sewers and force mains should have a minimum separation of 6 feet from potable water mains unless they are encased in concrete as per Arizona Department of Environmental Quality (ADEQ) requirements.

Manholes with sewers intersecting at greater than or equal to 90-degree angles should provide 0.2 feet of invert drop across the manhole. Other manholes should provide a minimum 0.1 feet of invert drop.

5.8 PIPE EVALUATION AND DESIGN

When designing sewers, it is common practice to adopt variable flow depth criteria for various pipe sizes. This criterion is expressed as a ratio of maximum depth of dry weather flow to pipe diameter (d/D). Design d/D ratios typically range from 0.5 to 1.0, with the lower values typically used for smaller pipes that may experience flow peaks greater than planned or may experience blockages from debris.

It is recommended that new sewer pipes be sized for 80 percent full during peak hour flows for diameters greater than or equal to 12 inches, and for 50 percent full for smaller diameters, for peak hour dry weather flow conditions. Existing sewers will be evaluated based on a flow depth criteria of 0.9 at peak hour flows because there are fewer unknowns, especially in established, built out areas, and because there is no need to replace or provide relief for an existing sewer until flows are at the maximum design capacity of the pipe.

The hydraulic criteria used for sizing the proposed gravity sewers will have a greater factor of safety than the criteria used to evaluate the capacity of the existing system due to the uncertainties in making projections of future flows. The proposed difference between the design criteria and the existing system criteria allows full use of the existing sewer capacities and prevents unnecessary pipe replacement. This approach avoids the problem of replacing or upgrading existing sewers prematurely.

5.9 WET WEATHER PEAK FACTORS

The Arizona Administrative Code also requires that any point in a sewer system be able to accommodate a peak wet weather flow by adding a wet weather infiltration and inflow rate based on either a percentage of peak dry weather flow or a gallons per acre rate of flow. One requirement of the Capacity, Management, Operation, and Maintenance (CMOM)

plans as defined in A.A.C. R18-9-C305 is to maintain sufficient capacity to convey base flows and the peak wet weather flow of a 10-year, 24-hour storm event.

The Maricopa County Flood Control District has published its Hydrology Drainage Design Manual, in which they have estimated the 10-year storm event in Peoria to vary between 2.3 and 2.7 inches over a 24-hour storm period. However, due to the large geographic size of the City's boundaries and the nature of storm patterns in the Phoenix Valley, it would be unreasonable to assume the full amount of a 10-year 24-hour rainfall would occur throughout the entire City limits. Portions of the City could see such rainfall totals and intensities while others experience lesser totals. Historical flow data of the collection systems' response to large storm events provide reasonable and valuable evidence of the amount of rainfall that actually infiltrates into the collection system.

Peoria's 2002 Wastewater Master Plan report used a wet weather peaking factor of 1.16 to estimate infiltration due to storm events. As discussed in Chapter 4, peak factors of 1.30 and 1.17 will be used in this 2007 Wastewater Master Plan update for the southern planning areas and northern planning areas, respectively. The differences in factors can be attributed to advanced construction materials and methods in newer portions of the City and older infrastructure in the southern portion is more likely to have more infiltration and illegal stormwater connections.

Design and evaluation of proposed of future sewers should include the wet weather factor applied to peak hour flows. However, due to the infrequency of wet weather, it may be more appropriate to allow pipes to be fuller, or have a higher flow depth criteria, when passing these additional storm flows. For purposes of this study, new pipes were evaluated to allow a flow depth criteria of 0.8 for dry weather peak hour flows and 0.9 for wet weather peak hour flows. Existing pipes were evaluated to allow a flow depth criteria of 0.9 for dry weather peak hour flows and up to, but not exceeding, 1.0 for wet weather peak hour flows. Allowing pipes to flow at higher capacities during wet weather events allows the City to be able to design and accommodate wet weather events without unduly stressing capital budgets with upsizing existing pipes or over-sizing future infrastructure.

5.10 CRITERIA SUMMARY

Table 5.3 summarizes the performance and design criteria used to evaluate the wastewater system.

Table 5.3 Wastewater System Criteria Summary
City of Peoria 2007 Wastewater Master Plan

Description		Criteria	
Pipe Size (inches)	**Minimum Slope[(1)(2)] (ft/ft)**	**Pipe Capacity[(3)]**	
		(mgd)	**(cfs)**
8	0.0050	0.45	0.70
10	0.0025	0.70	1.09
12	0.0020	1.02	1.57
14	0.0016	1.38	2.14
15	0.0015	1.59	2.45
16	0.0014	1.80	2.79
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Note:
(1) Slopes are calculated using Manning's Equation for pipes flowing full with a minimum velocity of 2 fps for all diameters except for 8 inches for which the minimum slope corresponds to 2.5 fps.
(2) Sewers larger than 24 inches should have a slope ≥ 0.0008.
(3) Pipe Capacity based on full pipe flow.

Flow Velocity in feet per second (fps)	
Gravity Mains	2 fps ≤ V ≤ 6 fps* * *For controlling odors* Maximum of 8 fps
Force Mains	3 fps ≤ V ≤ 7 fps
Flow Depth, d/D, (for dry weather peak hour flows)	
d/D for New Sewer Pipes with Diameters less than 12 inches	= 0.50
d/D for Designing New Sewer Pipes 12 inches and higher	= 0.80
d/D for Evaluating Existing Mains in Developed Areas	= 0.90
Wet Weather Factors (applied to peak hour flows)	
In the Southern Planning Area	1.30
In Northern Planning Areas	1.17
Flow Depth, d/D, (for wet weather peak hour flows)	
d/D for Designing New Sewer Pipes 12 inches and higher	= 0.90
d/D for Evaluating Existing Mains in Developed Areas	< 1.00
Headloss in Existing Pipes	
Gravity Pipes	Manning's N = 0.013
Pressure Pipes	Hazen William's C = 120
Changes in Pipe Size	
When a smaller sewer joins a larger one	Sewer crowns will be matched
Headloss at Manholes	
Manholes with pipelines intersecting at 90 degrees or greater	Provide 0.2' Invert Drop
Manholes with pipelines intersecting at less than 90 degrees	Provide 0.1' Invert Drop