

## 9. Vertical Alignment - Pipe Slope.

### a. General.

- 1) Design grades to minimize excavation, while satisfying the minimum and maximum velocity, clearance, and depth requirements.
- 2) Consider the following maintenance concerns when determining pipe grades.
  - a) Very steep grades, low flat grades, deep drop connections at manholes, etc., may save initial costs, but the savings will likely be offset by the increased long term costs of maintaining the system.
  - b) For release of Hydrogen Sulfide ( $H_2S$ ) caused by changes in grade or by drop connections at manholes, see requirements in Part Two, Section 16 (Manhole Drop Connections) and Section 29 (Hydrogen Sulfide ( $H_2S$ ) Control).
  - c) Problems with silt and grease build up when the flow exits from a steep pipe grade and enters a pipe on a flat pipe grade. Balance the pipe slopes to provide a more constant grade.
- 3) Provide continually increasing sewer pipe sizes running downstream. When the slope of the sewer changes and a decreasing pipe size can handle the flow, at the sole discretion of WSSC, the sewer pipe size can be reduced by one pipe size.
- 4) See Part Two, Section 15 (Pipe Slope and Manhole Distance) for pipe slopes ten (10%) percent or greater.

### b. Minimum Pipe Slopes.

- 1) Minimum pipe slopes, see Table "11".

**TABLE "11"**  
Minimum Pipe Slopes

Pipe Sizes	Minimum Slope
4-inch and 6-inch SHCs	2.00%
8-inch Terminal Sewer Mains	1.00%
8-inch Sewer Mains	0.60%
10-inch Sewer Mains	0.46%
12-inch Sewer Mains	0.34%
15-inch Sewer Mains	0.24%
18-inch Sewer Mains	0.19%
21-inch Sewer Mains	0.14%
24-inch Sewer Mains	0.12%
30-inch Sewer Mains	0.10%
36-inch Sewer Mains	0.07%

- 2) Table "11" is based upon Manning's Formula,  $n = 0.013$  and a velocity of two and one-half (2.5) fps for self cleaning velocities at half capacity flows.



- 3) For pipe sizes larger than 36-inch diameter, use the above requirements and submit hydraulic calculations in support of the sewer design.
- 4) Do not **increase** the diameter of the sewer pipeline to suit the minimum slope as shown on Table "11".
- 5) No exceptions to changing the minimum slopes.
- 6) Pipe sizes larger than 12-inch, submit the pipe slope design data calculations.
- 7) For additional requirements see Part Two, Section 2 (Pipe Size and Materials (Gravity Sewer)) and Appendix C (WSSC Design Criteria for Sewer Systems) for Hydraulic Design for Sewer Pipelines.
- 8) Slopes greater than those shown in Table 11 are desirable.

**c. Maximum Pipe Slopes.**

- 1) Submit a statement to WSSC, stating that all the pipeline velocities are under fifteen (15) fps.
- 2) When the pipeline velocity is fifteen (15) fps or greater, see design requirements for high velocities in pipelines under Part Two, Section 15 (Pipe Slope and Manhole Distance).

**d. Steep Pipe Slopes to Flatter Pipe Slopes.**

- 1) When steep pipe segments are followed by sections with flatter slopes, problems may occur. (Debris accumulating, surcharging and/or potential for hydrogen sulfide generation).
- 2) For sewers 12-inch and smaller and when incoming pipe slopes are over five (5.00%) percent, but under ten (10.00%) percent and the outgoing slope is one and one half (1-1/2) less than the incoming slope, change the pipe slope by reducing the pipe slope over the next sewer segment.

Example: If the incoming slope is set at 6% make the next down stream sewer segment at 3% before going to a flat slope.

- 3) For sewers 12-inch and smaller and when incoming pipe slopes are over ten (10.00%) percent and the outgoing slope is one and one half (1-1/2) less than the incoming slope, change the pipe slope by reducing the pipe slope over the next two (2) or three (3) sewer segment.
- 4) For sewers greater than 12-inches, submit hydraulic calculations in support of the sewer design.

