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F 300 ALIGNMENT OF SEWERS

The alignment of sewers shall be determined by the need for sewer service, environmental constraints and economic feasibility. There are three major elements to a sewer alignment: (1) the route selected, (2) the horizontal alignment and (3) the vertical alignment. Each element needs to be considered in detail to ensure an economic alignment that provides the service required.

F 310 ROUTE SELECTION

The route or streets to be traversed by a proposed sewer is normally based upon sewer deficiency studies and demand for sewage service. Proposed sewer projects annual 5-year CIP.

F 311 ROUTE INVESTIGATION

The Designer should review the sewer project route immediately upon assignment of the project. Environmental considerations should be on file in the division or district office. The sewer project is generally Categorically Exempt. (See F 140, et seq.) The need for the sewer project and the economic feasibility should not be different than originally intended.

F 312 FIELD RECONNAISSANCE

A field reconnaissance should be made to identify any changes in the conditions since the sewer project was initially conceived and approved for inclusion as a Capital Improvement Project. Depending on the project size and complexity the following may be investigated:

a. Area to be served.

b. General Topography. (Preliminary investigation may vary from a casual observation of field conditions to a detailed topographic and geological study).

c. Nearest available outlet sewers.

d. Location and size of large surface and subsurface obstructions and improvements.

e. Size and number of existing buildings (including basements).

f. Zoning.

g. Future development of the area.

h. Present and predicted population and land use.

The following references generally are available to prepare preliminary plans:

a. Drainage Maps
b. "Wye" Maps
c. District Maps (or Cadastral Maps)
d. "S" (Sewer) Maps
e. Substructure Maps
f. Field books (Survey)
g. City Planning and Regional Planning data
h. U.S.G.S. Topographic Maps
i. Aerial Photographs
j. Flow Gauging Records
k. U.S. Census Data
l. Construction plans of existing improvements
m. Sewerage Construction Program Notes

F 312.1 USE OF PHOTOGRAPHS

Photographs should be taken of the route selected for reference purposes. Surface culture such as large overhanging trees, as well as, congested vehicular traffic, classes of property development, etc., should be recorded with the photographs. Aerial photographs on file with the Survey Division may be utilized. The date of such photograph(s) may be important since culture may have been removed or added and vegetation may have grown to larger proportions since the photographs were taken.

F 312.2 FIELD NOTES FOR THE PROJECT FILE

The preliminary planning may reveal important alignment and design considerations that should be carefully noted. An example would be concrete pavements with thickened construction joints or large and irregular cracking that may necessitate extra pavement removals. In commercial or industrial areas access driveways may require continuous service. Field measurements may be taken. In most situations, a preliminary sewer survey will be required. Any indications of cut and fill conditions along the route should be recorded.

F 313 EVALUATION MATRIX TO ASSIST IN PIPELINE ROUTE SELECTION

The pipeline route selected for a sewage collection system determines to a large extent the cost of the collection system. The evaluation matrix is a method to select the most cost-effective pipeline route when alternative alignments are possible. The first step in the evaluation requires selection of the alternate routes and development of criteria to be used to evaluate the alternatives. Criteria used in the route selection may include those shown in Table F 313 or other criteria as determined by the engineer. A relative weight is then assigned to each of the evaluation criteria to reflect the relative importance of each criteria. This is largely based on engineering judgement and may vary with the characteristics of each project. Total weighting should total 100. The criteria are then graded with the following grading system (1=very poor; 2=poor; 3=average; 4=good and 5=very good). The criteria weighting is then multiplied by the grade to give a score for each evaluation criteria and alternate route. The route with the highest score is ranked number one and so on. This approach assists the Engineer in evaluating both economic and non-economic factors in selection of a optimum route.

F 314 SEWERS WITHOUT AN OUTLET (DEAD SEWERS)

Sewers shall not be constructed in any separate sewer district which has no available outlet until "Definite Provisions" have been made for an outlet. Exceptions to this order shall be made only by order of the City Council or Board of Public Works.

"Definite Provisions" relative to outlets within the City of Los Angeles shall mean that the actual construction of the outlet sewer is assured by a bond posted with the City for said construction under "B" Permit procedure; or that a sewer to be constructed under Assessment Act procedure has successfully passed the protest period and that the final ordinance has been adopted by the City Council; or that the outlet sewer is financed.

In relation to outlets within the County or other municipality, "Definite Provisions" shall mean that a contract for said sewer construction has been executed and that the necessary agreement or approval by the County or municipality has been consummated.

F 320 PRELIMINARY ALIGNMENT

Most small sewer projects do not require a preliminary alignment plan because the alignments are usually simple and the existing conditions are known. However, larger sewer projects involving several blocks and traversing different streets, will require a Preliminary Plan. The alignment involves designing a horizontal center line and a vertical gradient that will minimize cost.

F 321 THE HORIZONTAL ALIGNMENT

The most economical horizontal alignment will, generally, be the shortest length possible. The alignment may be varied to accommodate utilities, to maintain traffic safety and convenience, to equalize HC lengths on either side and to minimize other appurtenant work. The goal should be a horizontal alignment that fulfills the City's obligations to the public and utility companies, yet represents the shortest and most economical length possible. The Engineer should use all surveys and existing records, such as, cadastral maps, Sewer Wye Maps, record and survey field books and other data available in the BE and other offices and agencies in identifying the most feasible alignment.

F 321.1 MAPS

The BE maps contain useful information on existing improvements and conditions that might affect the horizontal alignment. In most cases a plan, profile or survey field book reference number can be extracted from the maps.

F 321.2 SURVEYS

Field survey records shall be researched to determine if there is recent data that may be useful for the sewer project. Aerial topographic maps may be available for most undeveloped areas. If existing records along with the District/Cadastral Map (See F 321.1) are not adequate, a survey may be ordered. See Part J, Chapter J 100 of the Bureau Manual for survey work request requirements. See J 452 for Preliminary Sewer Surveys.

F 321.3 SUBSTRUCTURES

The Engineer shall check all substructures to ensure sufficient vertical and horizontal clearance for the proposed sewer. Most substructures are the property of franchised utility companies. Every feasible alternative to avoid relocation of utility substructures should be pursued to minimize overall project costs. If, by avoiding substructures, sewer construction costs to the City are excessive, the utility owner shall be requested to relocate its interfering substructure. (See F 497)

Except under unusual circumstances, the sewer shall be located so that no portion of the existing substructure lies closer than 1-foot (horizontally and vertically) from the limits of the sewer trench. The width of the sewer trench, for this purpose, is defined by the Standard Plan S-251 titled "Pipe Laying in Trenches". It is assumed that the trench walls are plumb for this purpose. Water mains for potable water require special review in pursuit of State hygenic requirements. (See F 321.34 et.seq.)

Close proximity to parallel electrical conduits and to high pressure water mains, gas, and oil lines and other high pressure mains shall be avoided, if possible, because of the hazards involved during construction. If the sewer to be constructed is in close proximity to a thrust block of a pressure main, the owner of the main shall be consulted and involved.

When practical, avoid long-skewed crossings under existing substructures. They are very costly because of the amount of tunneling, difficult excavation and special supports required.

F 321.31 SUBSTRUCTURE RECORDS

The district offices maintain substructure record maps. The maps are kept current to the extent possible. The Engineer shall substantiate each substructure in detail. Recent utility company excavation permits show detailed substructure installations. These permits are checked by public counter engineers for conflict with proposed sewers. In all instances, the Engineer shall request utility companies for a current map showing their facilities within the project area.

F 321.32 UNSTABLE SUBSTANCES

An unstable substance is defined as "any substance carried by a subsurface installation which, if permitted to escape, could pose a hazard to public health or safety." This includes petroleum distillates, such as, butane and propane; oxygen, chlorine, steam, natural gas at a pressure exceeding 60 psig, any corrosive or toxic substance, all liquids in transmission lines and any other substructure conveying unstable substances which cross a proposed excavation or parallel to it and within 6 feet of a proposed sewer. All such substructures shall be exposed (potholed) sufficiently by the owner upon direction of the Engineer to determine their precise horizontal and vertical locations. A "no-fee" excavation permit shall be transmitted to the utility owner with the "pothole" request. The permit will include directions limiting the use of power tools to breaking of pavement only.

F 321.33 VERIFICATION OF SUBSTRUCTURE DATA

Two sets each of the Preliminary and Final Plans delineating all known substructure information shall be transmitted to utility owners for verification of location and identity of their facilities. The substructure owner shall be requested to review and provide comments within a 2 week time period. Upon receipt of such comments, the comments shall be documented and filed and the plans shall be updated to reflect the comments received from the substructure owners. Additional investigation including "Potholing" may be warranted.

F 321.331 POTHOLE INFORMATION

Substructures, other than those conveying unstable substances, may be ordered potholed. All information determined by potholing shall be shown on the project plans, including horizontal location ties and the exact elevations of the top and the bottom of the substructure. If the substructure is encased with concrete, the exterior dimensions of the encasement shall be shown.

F 321.332 UTILITY COORDINATION

The Engineer shall be responsible for accurately locating all existing utilities on the plans and resolving construction problems involving utilities.

The Construction Division, Utility Coordination Section, shall coordinate with the Engineer in obtaining utility information, notifying the utility companies of impending public works projects, coordinating utility work, organizing pre-construction meetings and meetings to resolve any utility interference problems that may arise during construction.

F 321.333 "AS-BUILT" SUBSTRUCTURES

The substructure owner is responsible for filing "As-Built" plans of underground facilities with the appropriate district office. The "As-Built" plans shall indicate all relocated and/or abandoned facilities.

F 321.334 PRE-ADVERTISEMENT CHECK

Prior to advertisement for bids, a final review shall be made to determine if recent or proposed installations necessitate a plan revision.

F 321.335 SPECIAL PROVISIONS OF NOTICE TO BIDDERS

The Construction Division shall be requested to include a provision in the Special Provisions of the contract documents or Notice to Bidders that requires the contractor to pothole substructures conveying unstable substances (See F 321.32). See Guidelines for implementation of Ordinance #150,478.

F 321.34 CRITERIA FOR SEPARATION OF SEWERS AND WATER MAINS

The State Department of Health is concerned about waterborne disease outbreaks attributed to the entry of sewage-contaminated groundwater into the distribution systems of public water supplies. Therefore, sewers in close proximity to watermains shall be reviewed with the State Department of Health.

F 321.341 PUBLIC HEALTH CONSIDERATIONS

The water supplier is responsible for the quality of the water delivered to consumers and must take all practical steps to minimize the hazard of sewage contamination to the public water supply. Protection of the quality of the water in the public water system may be enhanced by the barrier provided by the physical separation of the water mains and sewer lines.

This section sets forth construction criteria for the installation of water mains and sewer lines to prevent contamination of the public water supplies from sanitary sewer failures.

F 321.342 BASIC SEPARATION STANDARDS

The California Waterworks Standards sets forth the minimum separation requirements for water mains and sewer lines. These standards, contained in Section 64630, Title 22, California Code of Regulations, specify:

a. Parallel Construction: The horizontal distance between pressure water mains and sewer lines shall be at least 10 feet.

b. Perpendicular Construction (Crossing): Pressure water mains shall be least one foot above sanitary sewer lines where these lines must cross.

c. Separation distances specified in (1) and (2) shall be measured from the nearest edges of the facilities.

d. Common Trench: Water mains and sewer lines shall not be installed in the same trench.

When water mains and sanitary sewers are not adequately separated, the potential for contamination of the water supply increases. Therefore, when adequate physical separation cannot be attained, an increase in the factor of safety should be provided by increasing the structural integrity of both the sewer pipe materials and joints.

F 321.343 EXCEPTIONS TO BASIC SEPARATION STANDARDS

Local conditions, such as available space, limited slope, existing structures, etc., may create a situation where there is no alternative but to install water mains or sewer lines at a distance less than that required by the California Water Works Standards. In such cases, alternative construction criteria as specified in F 321.345 should be followed, subject to the special provisions in F 321.344.

F 321.344 SPECIAL PROVISIONS

The special provisions for the separation of sanitary sewers and water mains are:

a. The Basic Separation Standards are applicable under normal conditions for sewage collection lines and water distribution mains. More stringent requirements may be necessary if conditions, such as, high groundwater exists.

b. Sewer lines shall not be installed within 25 feet horizontally of a low pressure (5 psi or less pressure) water main.

c. New water mains and sewers shall be pressure tested where the conduits are located ten feet apart or closer.

d. During the installation of water mains or sewer lines, measures should be taken to prevent or minimize disturbances of the existing line. Disturbance of the supporting base of the pipe line could eventually result in its failure.

e. Special consideration shall be given to the selection of pipe materials if corrosive conditions are likely to exist. These conditions may be due to soil type and/or the corrosiveness of the fluid conveyed in the conduit.

f. Sewer Force Mains:

1. Sewer force mains shall not be installed within ten feet (horizontally) of a water main.

2. When a sewer force main must cross a potable water line, the crossing should be as close as practical to the perpendicular. The sewer force main should be at least one foot below the water line.

3. When a new sewer force main crosses under an existing water main, all portions of the sewer force main within ten feet parallel to the water main shall be enclosed in a continuous sleeve.

4. When a new water main crosses over an existing sewer force main, the water main shall be constructed of pipe materials with a minimum rated working pressure of 200 psi or equivalent pressure rating.

F 321.345 ALTERNATIVE CRITERIA FOR CONSTRUCTION

The construction criteria for sewer lines or water mains where the California Waterworks Standards cannot be attained are shown in Figures F 321.345A and F 321.345B There are two situations which may be encountered:

a. Case 1 -- New sewer line -- new or existing water main.
b. Case 2 -- New water main -- existing sewer line.

For Case 1, the alternate construction criteria apply to the sewer line.

For Case 2, the alternate construction criteria may apply to, either or both, the water main and sewer line.

The construction criteria should apply to the HCs that cross over a pressure water main but not to those HCs that cross under a pressure water main.

Case 1: New Sewer Being Installed (Figures F 321.345A and F 321.345B)

Zone	**Special Construction Required for Sewer**
A	Sewer lines parallel to water mains shall not be permitted in this zone without approval from the responsible health agency and water supplier.
B	A sewer line placed parallel to a water line shall be constructed of: 1. Extra strength vitrified clay pipe with compression joints. 2. Plastic sewer pipe with rubber ring joints (per ASTM D3034) or equivalent. 3. Cast or ductile iron pipe with compression joints. 4. Reinforced concrete pressure pipe with compression joints (per AWWA C302-74).
C	A sewer line crossing a water main shall be constructed of: 1. Ductile iron pipe with hot dip bituminous coating and mechanical joints. 2. A continuous section of reinforced concrete pressure pipe (per AWWA C302-74) centered over the pipe being crossed.
D	A sewer line crossing a water main shall be constructed of: 1. A continuous section of ductile iron pipe with hot dip bituminous coating. 2. A continuous section of reinforced concrete pressure pipe (per AWWA C302-74) centered on the pipe being crossed.

3. Any sewer pipe separated by a ten-foot by ten-foot, four-inch thick reinforced concrete slab.

Case 2: **New Water Mains Being Installed** (Figures F 321.345A and F 321.345B)

Zone **Special Construction Required for Sewer**

A No water mains parallel to sewers shall be constructed without approval from the health agency.

B If the sewer paralleling the water main does not meet the Case 2 Zone B, requirements, the water main shall be constructed of:

1. Ductile iron pipe with hot dip bituminous coating.
2. Dipped and wrapped one-fourth-inch-thick welded steel pipe.
3. Reinforced concrete pressure pipe, steel cylinder type, per AWWA (C300-74 or C301-79 or C303-70).

C If the sewer crossing the water main does not meet the Case 1, Zone C, requirements, the water main shall have no joints in Zone C and be constructed of:

1. Ductile iron pipe with hot dip bituminous coating.
2. Dipped and wrapped one-fourth-inch-thick welded steel pipe.
3. Reinforced concrete pressure pipe, steel cylinder type, per AWWA (C300-74 or C301-79 or C303-70).

D If the sewer crossing the water main does not meet the requirements for Zone D, Case 1, the water main shall have no joints within four feet from either side of the sewer and shall be constructed of:

1. Ductile iron pipe with hot dip bituminous coating.

2. Dipped and wrapped one-fourth-inch-thick welded steel pipe.

3. Reinforced concrete pressure pipe, steel cylinder type, per AWWA (C300-74 or C301-79 or C303-70).

F 321.4 HORIZONTAL ALIGNMENT LOCATION

Generally, the preferred horizontal alignment for a proposed sewer having HCs is the street center line. This equalizes HC construction costs to property owners on both sides of a street. Where HCs are not involved, the alignment should minimize costs and conflicts with other substructures. The Engineer may use a computer program for all sewer center line alignment calculations. (See F 150 et seq.)

F 321.41 HORIZONTAL AND VERTICAL CURVES

It is preferable to have sewers constructed with a straight alignment between maintenance holes. Straight sewers are easier to inspect after construction, cleaning is less apt to damage a straight pipe, and it is easier to locate a sewer that is straight between maintenance holes.

There are, however, situations where it is practical and economical to construct sewer lines with curves between maintenance holes. These situations might be to avoid other substructures, to avoid excessive maintenance holes in curved and hillside streets or to avoid short radius in maintenance holes where high velocity flow may overtop the channel. A sewer following the centerline of a curved residential street usually provides less interference with other utilities. Whenever possible the sewer horizontal curve should be concentric with the street horizontal curve.

The minimum radius of curvature attainable is governed by the type of joint specified or permitted, by the pipe lengths, by the maximum bevel permitted, and by the maximum separation of the abutting pipe ends permitted on the convex side of the curved sewer. This separation of the abutting straight pipe ends on the convex side of the curve is termed the "pull" and the joint is called a "pulled joint".

When any portion of a vertical curve is located within the limits of a horizontal curve, the pipe joint is being pulled in two directions. The resultant joint deflection is greater than the deflection in either the horizontal or vertical plane. Care must be taken during design to be sure the true joint deflection does not exceed allowable limits. A useful equation in this respect is:

$$\text{Cos } R = \text{Cos } V \text{ Cos } H$$

where, R = Resultant or true joint deflection
V = Vertical joint deflection angle
H = Horizontal joint deflection angle

Consideration of the plane in which beveled joints are to be used is essential. Verification of these criteria during checking of shop drawings is also required. Shop drawings should indicate the elevation, station and direction and degrees of bevel at each pipe joint. Each piece of pipe shall be numbered and the top of pipe indicated. Stacking the line in the field at each joint will facilitate pipe placement to ensure construction within design limitations.

F 321.411 DEFLECTED STRAIGHT PIPE

With pipe installed in straight alignment and the joints in a home (or normal) position, the joint space, or distance between the ends of adjacent pipe sections, will be essentially uniform around the periphery of the pipe. Starting from this home position, any joint may be pulled to a maximum permissible joint opening on one side while the other side remains in the home position. The difference between the home and opened joint space is designated as the pull. This maximum permissible opening retains some margin between it and the limit for satisfactory function of the joint. It varies for different joint configurations and shall be checked with the pipe manufacturer.

Pulling a joint in this manner affects the angular deflection of the axis of the pipe, which, for any given pull is a function of the pipe diameter. Thus, given the values of any two of four factors: pull, pipe diameter, length and deflection angle, the remaining factor may be calculated.

The radius of curvature which may be obtained by this method is a function of the deflection angle per joint and the length of the pipe sections. Thus, longer lengths of pipe will provide a longer radius for the same pull than would be obtained with shorter lengths.

The radius of curvature is computed by the following equation:

$$R = \frac{L}{2\left(\tan 1/2\,\frac{\Delta}{N}\right)}$$

where:	R	=	Radius of curvature, feet
	L	=	Average laid length of pipe sections measured along the centerline, ft
	Î	=	Total deflection angle of curve, degrees
	N	=	Number of pipes with pulled joints
	Δ/N	=	Total deflection of each pipe, degrees

Using the deflected straight pipe method, Figure F 321.411 shows that the Point of Curve (PC) will occur at the midpoint of the last undeflected pipe and the Point of Tangent (PT) will occur at the midpoint of the last pulled pipe.

F 321.412 BEVELLED PIPE

Sharper curvature with correspondingly shorter radii can be better accommodated with bevelled pipe than with deflected straight pipe. This is due to the greater deflection angle per joint which may be used. In this case the pipe is manufactured longer on one side than the other and the deflection angle is built in at the joint. Also referred to as mitered pipe, it is similar in several respects to deflected straight pipe. Thus, shorter radii may be obtained with shorter pipe lengths; the maximum angular deflection which can be obtained at each joint is a function of both the pipe diameter and a combination of the geometric configuration of the joint and the method of manufacture.

These last two factors relate to how much shortening or drop can be applied to one side of the pipe. The maximum drop for any given pipe is best obtained from the manufacturer of the pipe since it is based on manufacturing feasibility.

The typical alignment problem is one in which the total Δ angle of the curve and the required radius of curvature have been determined. The diameter and direction of laying of the pipe are known. To be determined is whether the curve can be negotiated with bevelled pipe and, if so, what combination of pipe lengths and drop are required. Information required from the pipe manufacturer is the maximum permissible drop, the wall thicknesses of the pipe and the standard lengths in which the pipe is available. Any drop up to the maximum may be used as required to fit the curve.

Values obtained by the following method are approximate, but are within a range of accuracy that will permit the pipe to be readily installed to fit the required alignment.

$$\text{Tan}\,\frac{\Delta}{N} = \frac{L}{R + D/2 + t}$$

The tangent of the deflection angle,Δ/N required at each joint is computed by the equation:

where: Δ = Total deflection angle of curve, degrees
N = Number of bevelled pipe
L = The standard pipe length being used, ft
R = Radius of curvature, ft
D = Inside diameter of the pipe, ft
t = Wall thickness of the pipe, ft

The required drop in inches to provide the deflection angle, Δ, is computed by the equation:

$$Drop = 12\,(D + 2)\tan\frac{\Delta}{N}$$

The number of pieces of bevelled pipe required is equal to the length of the circular curve in feet divided by the centerline length of the bevelled pipe (L - 1/2 Drop). Minor modifications in the radius are normally made so this quotient will be a whole number.

If the calculated drop exceeds the maximum permissible drop, it will be necessary to either increase the radius of curvature or to use shorter pipe lengths. Otherwise special fittings must be used.

It is essential that bevelled pipe be oriented such that the plane of the dropped joint is at right angles to the theoretical circular curve. For this reason lifting holes in the pipe must be accurately located, or, if lifting holes are not provided, the top of the pipe should be clearly and accurately marked by the manufacturer so that the deflection angle is properly oriented.

It should also be noted that a reasonable amount of field adjustment is possible by pulling the bevelled pipe joints in the same manner as with deflected straight pipe. However, on public sewers, the spigot end of each bevelled pipe length shall be manufactured in such manner that the pipe can be joined without pulling the joints.

As indicated in Figure F 321.412, the PC falls at the midpoint of the last straight pipe and the PT falls one half of the standard pipe length back from the straight end of the last bevelled pipe. To assure that the PC will fall at the proper station, it is generally necessary that a special short length of pipe be installed in the line ahead of the PC. The contractor/pipe supplier shall furnish pipe layout shop drawings as per SSPWC.

F 321.413 VITRIFIED CLAY PIPE

Table 321.413 shows the minimum radius or curvature permitted for unbeveled vitrified clay pipe (VCP) sewers constructed on horizontal curves. The table shown is for ASTM C 425 joints.

The various conditions of pipe size, nominal pipe length, minimum radius of curvature, and maximum design deflection at each joint are also shown.

Table F 321.413
UNBEVELED CLAY PIPE ON CURVES - TYPE "D" & "G" JOINTS
(All deflections are based on ASTM C 425)

Pipe Diameter (Inches)	For Pipe Length (Feet)	Min. Radius of Curvature (Feet)	Max. Deflection per Joint (Degrees)
6 to 12	5	120	2.4
	5 1/2	132	2.4
	6	144	2.4
15 to 24	5	160	1.8
	5 1/2	176	1.8
	6	192	1.8
	7 1/2	240	1.8
27 to 36	5	240	1.2
	5 1/2	264	1.2
	6	288	1.2
	7 1/2	360	1.2
39 to 42	5	320	0.9
	5 1/2	352	0.9
	6	384	0.9

Where curves of shorter radii than those permitted in Table F 321.413 are necessary, the clay pipe may be beveled, or shorter lengths of pipe used, or a combination of the two may be used. The maximum bevel for Type "G" joints is 4 degrees. Where practical, curves should be selected so that the pipe length is not less than 4 feet. Type "C" joints shall not be used with beveled pipe.

For 18-inch diameter and larger sewers, the Contractor shall be required to submit shop drawings showing the bevel and pipe lengths he plans to use. In all cases where pipe lengths of less than 6-feet are required to conform to the above limitations, the maximum pipe lengths shall be shown on the sewer profile.

F 321.414 REINFORCED CONCRETE PIPE

Where reinforced concrete pipe (RCP) is to be laid on either a vertical or horizontal curve, the Contractor shall submit shop drawings for approval by the Engineer.

A pipeline may be constructed on a curve by using pipe beveled on the spigot end or by pulling the joints. Pulled joints may not exceed that recommended by the pipe manufacture or shown on the shop drawings.

Information concerning standardized bevels may be obtained from the RCP manufacturers. The maximum bevel for City RCP sewers shall be 4 degrees. The maximum offset at the invert between adjacent interior surfaces across a joint shall be 1/4-inch for pipe with bevels of 3 degrees or less, and 3/8-inch for pipe with bevels between 3 degrees and 4 degrees.

The maximum laying length of RCP shall be 16 feet. The minimum laying length shall be 8 feet. Shorter length RCP may be specified for specific situations. The lengths and bevels shall be shown on the shop drawings.

F 321.415 DUCTILE IRON PIPE

When it is necessary to construct a ductile iron pipe (DIP) sewer on a curve, the Division or District Engineer shall determine the types of joints to be specified or permitted.

F 321.416 PLASTIC PIPE

Pulled joints or beveled pipe ends to achieve curvature for plastic pipe should not be done. Bending of solid wall plastic pipe to achieve vertical or horizontal curves without using deflection fittings, shall be limited as follows:

Nominal Pipe Diameter (inches)	Minimum Radius (feet)
6	210
8	280
10	350

12	420
15	525

Curves of radii less than shown above can be achieved with 3 or 5 degree deflection fittings.

F 321.42 CENTER LINE SEWER ALIGNMENT TIES

Proposed sewer center lines shall be tied by dimensions and stations to the street center line and other similar features with appropriate field book references. All BCs, ECs, and PIs of horizontal curves shall be tied to these same references.

F 321.43 MAJOR STREET AND TRAFFIC CONSIDERATIONS

Traffic in major and secondary highways and collector streets shall be given special consideration. Any traffic problems anticipated during construction shall be discussed with the LADOT traffic programs and traffic management at the earliest date possible. If a choice of several equally satisfactory routes is possible, a route should be selected in which the construction and maintenance will cause a minimum of delay and inconvenience to pedestrian and vehicular traffic.

Large deep sewers require big trenching and excavating equipment. In streets which have narrow roadways, the sewers must be so located that the contractor will have sufficient room to operate a trencher, trucks and other large equipment. It may be impractical to construct a large or deep sewer in a narrow street. The need for temporary construction easements should be considered in studies of sewer locations where insufficient working space is a problem.

For streets approximately 100 feet wide or wider, the use of two parallel sewers to minimize HC excavations may be necessary. In streets where traffic volume is considerable, the Department of Transportation (DOT) traffic control requirements should be considered prior to deciding the horizontal location for the sewer. The type of pavement and major longitudinal construction joints in the pavement should also be considered.

F 321.44 GUTTERS

Sewer center lines shall not be located closer than 4.5 feet from any street gutter flowline unless circumstances require a closer location, in which case the approval of the District/Division Engineer shall be required. This practice reduces storm drainage inflow into the maintenance holes, allows excavation of the sewer without removal of the curb and gutter and allows the construction of other utilities near the gutter. This area is also restricted by policy to other utilities.

F 321.45 STREET PARKWAY CULTURE

Sewers shall not be located in the street parkway (the area between the curb and the property line). This area is normally reserved for public works utilities. An allowable exception would be where the street is scheduled to be widened and the future gutter clearance would be attained. (See F 321.44 and Standard Street Dimensions Standard Plans). Sewer alignments should be located as far away from large existing trees as economically possible to avoid or minimize overhead branch interference and large root cuttings during construction and possible future damage to the sewer by root intrusion.

F 322 VERTICAL ALIGNMENT

The sewer vertical alignment shall account for substructures, basement elevations, low ground and general terrain of the area being served. Generally, the shallowest vertical alignment will be the most economical with a depth of 8 feet commonly used. The minimum HC depth shall be 4 feet at the property line measured from the top of the curb. The vertical location of the sewer shall accommodate substructures, especially substructures carrying unstable substances and potable water mains. (See F 321.32)

F 322.1 MINIMUM GRADE

The minimum grade of a proposed sewer shall provide a minimum velocity of 3 fps at PDWF. (See F 253)

F 322.2 VERTICAL CURVES

Grade changes (GC) are usually limited to subcritical flows. Where flow is supercritical, especially when the flow changes from supercritical to subcritical a Vertical Curve (VC) may be preferable to a GC. Where a hydraulic jump could occur a VC shall be mandatory. (See F 242)

The cost of constructing a sewer on a VC is greater than a GC and the excess cost should be considered in making the decision to provide a VC. Additionally, a VC should be provided if it will reduce an excess cut and/or fill. VCs may be either a circular curve or a parabolic curve. All VCs, except for a few cases, are a series of short chords. Where possible, a circular VC should be provided. The greatest advantage of a circular curve is it allows all joints to be pulled the same amount, thereby, greatly facilitating the construction procedures.

Parabolic curves are easier to calculate insofar as the offset or pull in a joint is concerned, however, it is more difficult to construct as the pull in each joint must be separately calculated because each joint will have a different pull. Another problem involved in parabolic curves is the length of sewer pipes manufactured. With the advent of various plastic pipes, the length varies between different manufacturers of the same pipe material. Parabolic curves should be provided where the flow is supercritical or where a hydraulic jump may occur. As a parabolic curve more closely approximates a water surface profile in a vertical transition, regardless of the invert slope, the utilization of a parabolic curve will allow a smoother transition of the water surface profile and thereby, minimize turbulence and other hydraulic losses. Additionally, it may eliminate, or at least reduce the effects of a hydraulic jump.

In very large sewers utilizing a cast-in-place box section, a parabolic curve is preferable, because there is no problem in pulling joints and the flow is sufficiently large to warrant the extra protection of a parabolic curve for minimizing of turbulence and hydraulic losses.

The following is an example for the computation of a parabolic vertical curve for a pipeline. Figure F 322.2 illustrates an example of a parabolic vertical curve and features of the vertical curve are defined as follows:

BVC = Beginning of Vertical Curve
EVC = End of Vertical Curve
PVI = Point of Vertical Intersection
g_1 = First pipeline gradient, ft/ft
g_2 = Second pipeline gradient, ft/ft
L = Length of Vertical Curve, ft
x = Horizontal Distance along the Vertical Curve, ft
y = Vertical Distance along the Vertical Curve, ft

$$y = \frac{g_2 - g_1}{2L} x^2 + g_1 x$$

The formula for calculating any elevation for a given distance along the curve is as follows:

The following example illustrates the computation of elevations for a parabolic curve at 16 foot intervals, assuming exact invert elevations are required for 8 foot lengths of pipe.

GIVEN: BVC = 100.0 ft (pipe invert elevation)
L = 160 ft
g_1 = -.02 ft/ft
g_2 = -.04 ft/ft

FIND: Pipe invert elevations at 8 foot intervals and PVI and EVC invert elevations.

SOLUTION: The parabolic vertical curve elevation may be computed as follows:

$$Curve\ Elev. = BVC\ Elev. + \frac{g_2 - g_1}{2L} x^2 + g_1 x$$

Vertical Curve Computations

STATION	x	x^2	$\frac{(g_2-g_1)x^2}{2L}$	$g_1 x$	Curve Elev.
1 + 00(BVC)	0	0	0.00	0.00	100.00
1 + 16	16	256	-0.02	-0.32	99.66
1 + 32	32	1,024	-0.06	-0.64	99.30
1 + 48	48	2,304	-0.14	-0.96	98.90
1 + 64	64	4,096	-0.26	-1.28	98.46
1 + 80(PVI)	80	6,400	-0.40	-1.60	98.00
1 + 96	96	9,216	-0.58	-1.92	97.50
2 + 12	112	12,544	-0.78	-2.24	96.98
2 + 28	128	16,384	-1.02	-2.56	96.42
2 + 44	144	20,736	-1.30	-2.88	95.82
2 + 60(EVC)	160	25,600	-1.60	-3.20	95.20

Parabolic curves may be specified or permitted with Type "C", or "G" joints for VCP. The limitations shown in Table F 321.413 shall be observed. The minimum horizontal length of a vertical curve which is required to conform to the minimum radii permitted may be computed as follows:

L min. = $(S_2 - S_1)$ R min.

Where:

L min. = Minimum horizontal length of vertical curve.(ft)

S_1 and S_2 = Slopes of tangents to the vertical curve expressed in feet per foot.

R min. = Minimum radius of curvature permitted (ft); based on type of joint, pipe size and maximum pipe length. (See Table F 321.413 for VCP)

F 322.3 SUBSTRUCTURES

Every effort to clear existing substructures should be made. (See F 321.3). For design purposes, the concurrence of the substructure franchisee should be secured. A minimum clearance of 1 foot (horizontally and vertically) between the outside of the substructure and the sewer pipe should be maintained. See Standard Plan S-253 for supporting sewer and storm drain conduits across trenches and Standard Plan S-255 for blanketing a conduit under a proposed sewer.

All existing SDs, as well as, large water mains and large banks of power and telephone conduits, should be investigated for adequate clearance from the proposed sewer before commencing final alignment studies.

F 330 GEOTECHNICAL SERVICES

The effect of trenching for sewer construction on the stability of streets or sewer easement areas and their adjacent slopes shall be carefully investigated in the design of sewers. It should be an item for the Preliminary Design Conference Agenda.

When sewers are to be located in hillside or mountain areas, Project Engineers shall investigate the proposed locations to determine whether hazardous conditions exist for usual construction methods. If it appears there is a probable hazard, and upon concurrence of the District or Division Engineer, a report on the geological and soils conditions with recommendations shall be requested from the Geotechnical Services (G&S). The Department of General Services Standard performs all field tests requested by the BE.

F 331 DETERMINATION OF GEOLOGIC AND SOIL CONDITIONS

A G&S Report should be requested for all proposed sewer projects. Data from existing reports made for other projects in the sewer area may be available and should be investigated. Requests for tests and reports for geologic and soil conditions shall be transmitted to the G&S Section of the Construction Division.

The request for a G&S report shall be in writing. The memorandum should transmit the preliminary plan and profile with sufficient horizontal ties and all known utilities and HCs shown to determine the precise location for sampling and testing. Any special test data, such as, gas seepage when tunnel work is proposed or groundwater seepage rates, shall be specifically requested.

Test holes will usually be requested along the center line of the proposed sewer at approximately 500-foot intervals. It shall be the responsibility of the Project Engineer to locate the test holes correctly in plan and profile on the drawings. Where pavement thickness is uncertain, sewer centerline cores may be requested to determine pavement thickness and composition.

F 331.1 G&S SECTION

The G&S Section shall submit the preliminary plan and profile to utility owners for locations of their facilities in the vicinity of the location selected for sampling. After receiving this data, the G&S Section will transmit the soil boring request to Standards. When the field tests have been completed and the data has been transmitted to the G&S Section, a G&S Report shall be prepared for the project. Copies shall be submitted to the Design Office and/or the Structural Engineering Division (SED) as directed in the communication.

F 331.2 STRUCTURAL ENGINEERING DIVISION

The Structural Engineering Division's (SED) need for specific soil data on a sewer project is normally included with the request for a G&S Report. The SED should be contacted prior to submitting the request to determine any special G&S data that they may need. The SED shall use the report and test results to check the structural integrity of the sewer pipe and appurtenant structures and to recommend any requirements for inclusion in the project's Special Provisions.

F 331.3 CHANGE OF SEWER ALIGNMENT

If the Preliminary Design Conference does not reveal a possible alternative alignment, the results of a G&S report may indicate a need to consider one. The G&S Section or the SED may recommend a change if unstabilized fill, expansive soils, rock, peat or geologic or seismic faulting will be encountered at the proposed sewer location.

F 332 SOIL BORINGS

All sewage projects extending 500 feet or more in length should have two or more soil borings. All soil borings are made by the City Bureau of Standards. Based on specific knowledge of the area, the Engineer shall determine the number of borings and the extent of soil testing requested. If unsuitable material is anticipated (or encountered while boring), the request should include instructions to take more borings to locate the limits of this material.

A plan and profile showing substructures, with ties locating and numbering the soil borings, shall be transmitted to the Geology and Soils Engineering Section with the request. Should the borings be located outside of the surveyed area, their ground surface elevations must be taken. When locating soil borings, special consideration should be given to traffic hazards, overhead utilities, surface culture (trees, driveways, etc.), and adequate working space.

The purpose of the test borings and soil tests is to inform the Engineer and Contractor of existing ground conditions. Therefore, enough soil data shall be requested to determine the type, strata, and condition of soil; the ground water conditions and the presence of substances corrosive to concrete or steel. A soil analysis should be requested for each stratum of material unsuitable for trench backfill. Further tests for stability of excavated slopes, compacted fills, or other requirements are requested only when evidence indicates that such a problem exists. Figure F 332A The Unified Soil Classification System contains nomenclature to help the Engineer understand the soils report. Geological investigations shall be requested from the Geology and Soils Engineering Section of the Street Opening and Widening Division. The use of test borings previously taken for other projects in lieu of new test borings may not be reliable and should not be permitted. The log of test borings shall be shown on the plans as shown in Figure F 332B. These logs shall be taken verbatim from the soil report.

F 332.1 LOCATION, DEPTH, AND SPACING

Test borings shall be plotted on the plans and identified with a numbering sequence increasing upstream. Boring locations accessible by mobile equipment shall be selected when practical. In streets, borings are preferably located outside paved areas, in rights-of-way, they may be located at any point easily accessible. On private property proposed for a right-of-way, the Engineer should request the Bureau of Right-of-Way and Land to obtain rights of entry to take borings. On the plan sent to the Geology and

Soils Engineering Section, borings shall be tied from two directions from street centerlines, curbs, or other permanent improvements. Sewer pipeline shall not be used.

Test borings shall be carried to the following depth:

a. When no water is encountered, at least three feet below the proposed sewer invert.

b. When ground water is encountered, at least six feet below the proposed sewer invert.

Test borings shall normally be spaced at 500 feet intervals for the full length of the alignment, with a maximum spacing of 600 feet. The Engineer shall use closer spacing, however, when in his judgement this is required to define underground conditions more completely. Locations which usually require closer spacing of test borings are:

a. Areas of fill or dump sites
b. Slide areas or steep hillsides
c. Watercourses or low lying areas
d. Minimum length requiring test borings.

F 332.2 GROUND WATER AND SOIL TESTS

The log of borings must indicate the ground (or perched) water table, if any, showing the depth at which it was found and the date the boring was drilled. If the logs are plotted on a separate sheet rather than on the profile, the conduit invert must also be plotted at its proper depth. If no water is encountered, no water encountered should be printed below the log.

In certain locations, sulfates, alkalies, and salt water may be present. These are harmful to concrete and steel if found in sufficient quantities. Chemical analysis of the groundwater or soil sample should be made to determine the quantity of these substances present. The most active of these harmful substances are the sulfates, which shall be considered in the design when they are found in sufficient concentrations as shown in Table F 332.2. Chemical analysis of either groundwater or soil sample or at least one test hole per project should be requested when no previous tests in the area have been made. For large projects, analysis of every third test hole is recommended.

Table F 332.2

SULFATE CONCENTRATION HARMFUL TO CONCRETE

%Water-soluble sulfate (as SO_4) in soil samples	Ppm sulfate (as SO_4) in water	Relative degree of attack on concrete	Suggested Type of resistant concrete
to 0.10	to 150	Negligible	______
0.10 to 0.20	150 to 1000	Positive	Type II
0.20 to 0.50	1000 to 2000	Considerable	Type V
0.50 and over	2000 and over	Severe	Type V

Ref: Table 2, Concrete Manual, 7th Edition (1963), U.S. Bureau of Reclamation.

F 340 RIGHT-OF-WAY

Sewers shall be placed in public right-of-way whenever possible. If acquisition of right-of-way is necessary, see Parts C, E and K of the Manual for procedures and requirements.

F 350 APPROVAL OF ROUTE

The sewer route(s) are determined in conjunction with Wastewater Capital Improvement Program (WCIP) made by the District Engineers and compiled by the WPMD. Any reasonable change(s) from the funded project route(s) shall be subject to the approval of the District/Division Engineer. Project cost increases beyond the City Engineers cost change authority will require board approval.