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PRESSURE FLOW DESIGN (G 300)

LIST OF FIGURES

* Figures preceded by asterisks are in text. All others are at ends of chapters.

G 300 PRESSURE FLOW DESIGN

A pressure flow storm drain is designed to flow by force of gravity for the peak flow of a selected storm frequency. The conduit will not flow full for the greater part of the storm time, which is prior to or after the peak flow. This storm drain generally consists of pipe or box covered conduits, catch basin collectors, and other appurtenances.

The purpose of this chapter is to outline a method of design for pressure flow storm drains.

A procedure which coordinates the functions of the design office with those of other City offices (or other agencies) is suggested in the Flow Chart of Design Procedure (Figure G 314). It illustrates the complexity of interdepartmental design functions. Since the design engineer is responsible for initiating these functions and following them through to completion of the project, the use of this design procedure as a guide is strongly recommended.

G 310 DESIGN PROCEDURE

G 311 DESIGN AUTHORITY

Authority to proceed on the design of a project approved by the Board of Public Works is indicated by assignment of a work order number. All time used for design and processing of the project is charged to this number. The design engineer may not proceed on the design or checking of any project without proper authority. The designer should refer to the project file for the Board communication authorizing the project work order number.

G 312 EMERGENCY WORK ORDER REQUEST

Ordinarily, the design office requests a work order number from the Administration Division after a project has been authorized by the City Council. However, if a project is critical and design should start immediately, the design office shall request an emergency work order approval and prepare a board report requesting project authorization and public financing (if required) concurrently. Also, should a major change in the scope or financial requirements of a project occur, a revised work order request shall be made to the Administration Division. Refer to the Operations and Control Manual for the requirements and procedures of work order requests.

The forms Bureau of Engineering Work Order (Figure G 312) shall be used for work order requests. A class "C" estimate (Section G 033) is satisfactory for this form.

G 313 DESIGN CRITERIA

The three basic types of design criteria to which storm drains are subject are hydrologic, hydraulic, and alignment.

A. Design criteria which cause deviation from the standard storm frequency (Section G 222) are as follows:

l. Restriction of "Q" flowing in the street in order to prevent flood damage.

2. Restriction of "Q" outletting into a drainage facility of limited capacity.

B. Design criteria which control the elevation of the hydraulic gradient are as follows:

1. Ground Line: The hydraulic gradient should be below the ground line to prevent outflow from the conduit and allow inflow from catch basins and laterals.

2. Pressure Flow: The hydraulic gradient should be 0.3 feet above the conduit soffit to maintain pressure flow.

3. Inlet Control: The hydraulic gradient elevation at inlets must not exceed the highest water surface allowed to prevent backwater or inundation at sumps. This highest water surface is generally set from a determination of flood damage which would be incurred thereby.

4. Outlet Control: The hydraulic gradient elevation must be at the water surface of the channel or conduit into which the storm drain discharges. The channel or conduit water surface is generally above the soffit of the storm drain and will normally be the point of control for the start of hydraulic computations.

5. Velocity: The construction slope of the storm drain conduit should be sufficient to provide a minimum self cleansing velocity of 5 fps at half-full flow. Also, steep construction slopes should be avoided so that excessive velocities during part-full flow do not cause cavitation or abrasion in the conduit.

C. Design criteria which affect the vertical and horizontal alignment are as follows:

l. The horizontal alignment must be located within City streets or drainage easements.

2. The vertical alignment should be clear of existing subsurface or surface obstructions where economically feasible.

3. The alignment should allow for traffic requirements and maintain accessibility for construction.

G 314 DESIGN FLOW CHART

The design functions are illustrated in the Flow Chart of Design Procedure (Figure G 314). All these functions may not apply to the design of every project. The designer shall decide which functions apply according to the project requirements.

The objectives of the flow chart are as follows:

1. To make full use of the specialized knowledge of other bureaus or divisions;

2. To reduce design delays by requesting work from other offices as soon as the design data are available; and

3. To maintain continuous work and avoid duplication by organizing the sequence of design.
The blocks in the flow chart represent the design functions and are read from left to right. Blocks directly above other blocks indicate functions which may be done concurrently.

The designer should organize the best approach for his design, keeping in mind the requirements of the system. The functions of the flow chart should be reviewed to determine those which are applicable to the project. Strict adherence to the block sequence may be impractical because personnel may not be available or work from other offices may be delayed. If special problems are anticipated, a change in the sequence of the functions to better cope with these problems should be made. In any case, a planned sequence of design steps must be formulated.

For smaller projects, the designer may be expected to schedule his work. This consists of estimating the time required to complete the design, based on the complexity of the job and design experience available. Should complications delay the design, the supervisor should be advised of the change of design time required.

G 315 DESIGN CHECKING

All design functions shall be checked for accuracy and proper application. The survey and other data plotted on the plan and profile and on the drainage map shall be checked in the field for completeness. The runoff calculations, centerline calculations, and hydraulic calculations shall be independently checked for application and accuracy. The conduit alignment, catch basin locations, and outlet locations shall be checked in the field for interference with existing improvements. At key points in the design procedure (shown by an asterisk on Figure G 314), the design progress shall be checked by the supervisor before the design is continued. (See check sheets on Figures G 735A and G 735B and Section G 735.)

G 320 PRE-DESIGN DATA

Before undertaking the detailed design of a project, certain investigations must be made to acquire the necessary data for design. The proper selection of the drainage system and its alignment depends on the thoroughness and accuracy of these data.

G 321 PROJECT REVIEW

The project review consists in obtaining data from files and records, reviewing the scope of the project, and applying the information to check the drainage system and general alignment.

G 321.1 Files and Records: The project file. should contain the preliminary study, communications, and other information necessary to answer the following questions:

a. What is the purpose of the project?

b. Are there limitations on design or construction?

c. How much money has been allocated for the project?

d. Are there restrictions on the use of funds? (Sections G 031 and G 043)

e. What is the priority of the project? (Sections G 032 and G 041)

f. What previous work has been done on the project?

g. Has the project been combined with another?

The records searched by the designer for existing facilities or proposed improvements are available in the respective division or district offices. Those which show existing facilities are as follows:

a. Drainage maps, which show existing drains, watercourses, and ground contours.

b. District Maps, which show property lines, rights of way, and tract references.

c. Substructure Maps and Utility Company Atlases, which show utility substructures.

d. Sewer Record Maps and "Y" Maps, which show existing sewers and house connections.

e. Index to Plans and Profiles of existing improvements.

Record maps which show proposed improvements are as follows:

a. Master Plan of Drainage, City of Los Angeles

b. LACFCD Bond Issue Location Maps

c. Master Plan of Los Angeles City Sewerage System

d. Sewer Bond Issue Location Maps

e. Master Plan of Freeways

For proposed improvements from tracts, Capital Improvement Projects, or Assessment Projects, communicate with the design office of jurisdiction as outlined in Section G 020.

G 321.2 Project Scope: The basic considerations in determining the scope of a project are the extent of service provided, the effects of adjacent or related projects, and the financial limitations.

The extent of service to be provided by the project is given in the preliminary study (Section G 180) for conditions which existed at the time the study was made. The designer must determine if these conditions have changed and how they affect the service and cost of the project.

All existing or proposed projects adjacent or related to the proposed storm drain must be reviewed. The designer should procure plans of all existing improvements along the project alignment. Also, the City sewer, street, and structural design offices should be consulted for all proposed projects in the vicinity of the drain. Projects proposed by an agency other than the City are generally known by the City design office of jurisdiction. The information needed to determine the extent of interference by proposed projects is the alignment (or extent) of the project, the estimated date to contract, and (if available) a copy of the preliminary plans. If interference exists or if the projects supplement each other, they should be coordinated by the two design offices.

The funds appropriated to finance the proposed drain may have limitations on their use. Limitations may be those inherent in the specific fund (see Sections G 031 and G 040) or those established by the City Council (such as a set amount of money from a certain fund for a specific purpose). These are usually stated in the City Council agenda. For information on the status of financing for Capital Improvement Projects, refer to Project Status Report, published monthly by the Administration Division. If any conflict exists, such as one between limitations and design standards, consult the supervisor.

Should the scope of the proposed drain change, the funds appropriated may be inadequate. A change of scope may consist in a change in alignment, the need of a box conduit in lieu of a pipe, or any other change that would increase the cost of the project. The designer must review the cost of the project and if the cost is increased by 10% or more, a revised CAO-39 form must be prepared and transmitted to the Coordinating Division as shown in Section G 180.

G 321.3 Alignment: The alignment of the drainage system as proposed by the preliminary study must be reviewed before the field survey is requested.

The full length of the alignment should be checked in the field for new construction which would obstruct the proposed drain, especially in rights of way. New substructure installations (sometimes spotted by new trench resurfacing) should also be determined. The accessibility and available capacity of the outlet must be established.

If a freeway, tract, or other major development has been constructed (or is under design) which obstructs drainage facilities or changes the surface runoff, the new route of surface runoff must be determined from the freeway or tract hydrology and the alignment must be adjusted to incorporate the change. The alignment study must consider the entire watershed as fully developed, and the route chosen must provide for future extension for the ultimate construction of the entire system. Any deviation from this practice must have the specific approval of the supervisor.

The most desirable alignment is generally the shortest route which follows the streets carrying the largest surface flow, with laterals collecting the runoff from the outlying contributing areas. The major considerations in determining the alignment are the location of the outlet, the topography of the watershed, the right of way requirements, and the substructure and traffic interference. The capacity, hydraulic properties, and physical characteristics of the outlet should be investigated to determine what influence they may have on the alignment.

A study of the watershed topography should be made to take advantage of natural grades in the interception of runoff concentrations. Excessive excavation, flat grades requiring large conduits, and extensive right of way acquisitions are all costly. The use of streets parallel to the surface flow is very efficient because of the time lag between the peak flow in the drain and the peak of the slower street overflow that follows. The street chosen, however, must be large enough to allow the construction of the storm drain without excessive substructure or traffic interference.

G 322 FIELD SURVEY

The designer should request a field survey within the same time limit (given in Section G 323) which is allotted for the filing of the Preliminary Engineering Report. Like the Preliminary Engineering Report, the investigations required to set the general alignment of the project should be completed prior to requesting the field survey.

All storm drains designed by the City should be based on field survey data furnished by the Survey Division. For most storm drains, the Storm Drain Profile survey as shown in Chapter IX of the Survey Manual is sufficient. The survey is requested on the standard form Request for Field Work shown in Figure G 322.

Before preparing the survey request, previously submitted survey requests for similar projects should be reviewed and the Survey Division should be consulted about recent surveys in the area. All surveys used for a project should have a common level bench. For extensive alignments, a sketch of survey limits should be submitted with the request. For combined street and storm drain projects, the survey requested for street design is usually adequate for storm drain design.

The extent of the field work required must be determined to eliminate additional survey work later. Of course, the survey must cover the full length of the storm drain alignment, but for most cases, this is not sufficient. For example, the hydraulic calculations and the plan detailing of inlet and outlet structures in a watercourse require a survey of existing grade and alignment for a considerable distance beyond the project construction limits. Usually, supplemental street cross-section survey for catch basin capacity design is more conveniently performed by the design squad. A general review of the design problems is recommended before the limits of survey field work are set

G 322.1 Photogrammetry: Photogrammetry to supplement conventional surveys should be used if considered useful in a particular project. The procedure to acquire Photogrammetry is as follows:

1. The design office will consult the Survey Division to discuss the requirements of the proposed project, such as ground control, map scale, type of maps, and pictures to be obtained.

2. After the discussion, the design office will prepare a vicinity sketch, normally on a drainage map reproduction, showing the limits if the area to be mapped and a sample title block. This sketch will be forwarded to the Survey Division. which

will confer with prospective photogrammetrists. A representative from the design office should attend such conferences.

3. Upon completion of the work, a copy is transmitted to the design office for review. The review is returned to Survey Division with comments if the survey is not satisfactory. The Survey Division will see that the necessary corrections are made and return the completed survey to the design office, which will retain the photographs.

When the survey is to be used for a special application, such as an aerial survey for right of way description, the purpose of the survey should be stated in the request.

G 323 PRELIMINARY ENGINEERING REPORT

The designer shall prepare a Preliminary Engineering Report (Figure G 323) on all projects upon completion of the pre-design investigations.

The report should be filed:

a. within 30 days after the work order is approved for Capital Improvement Projects; and

b. within 60 days after the petition is filed or the Council Resolution is passed for Assessment Projects.

Where extensive alignment or other studies are required, this time may be extended with the permission of the supervisor. For the distribution and revision of this report, consult the Operations and Control Manual.

The purpose of this report is to notify the Board of Public Works and the Bureau of Right of Way and Land of design status to expedite completion of CIP and Assessment projects. All copies are transmitted to the Administration Division for distribution except for one copy, which is transmitted to the Projects Control Division. A joint field trip with the Bureau of Right of Way and Land is not required for this report.

The Estimated Cost is taken from the Preliminary Estimate Sheet (Figure G 185) or the work order estimate. All items under A, B, and C should be marked based on the designer's intimate knowledge of the area and the project files.

When it cannot be determined that an item is involved at the time of report preparation, it should be listed as possibly involved.

G 324 NOTICE TO TRAFFIC AND STREET LIGHTING

The design office shall notify the Department of Traffic and the Bureau of Street Lighting when design is started on Capital Improvement Projects. The notice will furnish the necessary data to schedule the projects and expedite their portion of the design.

The notice shall consist of a sketch of the proposed project indicating the limits and scope of the improvements as well as the estimated completion date of the preliminary plans. A print of the sketch used with the CAO-39 form is satisfactory.

Should the scope of any project change after the initial sketch is submitted, the design office shall immediately notify the Department of Traffic and the Bureau of Street Lighting, indicating the changes made.

G 325 STREET GRADES

When official grades do not exist for streets, alleys, and walks under which a storm drain is proposed, the designer shall request that the grades be established. In the Central District, the grades are established by the Street and Freeway Design Division. The request is made by interoffice memo, transmitting therewith the necessary sketches or data required. In all other Engineering Districts their Street Design Section establishes the grades.

The main reason for establishing street grades along the storm drain alignment is to coordinate the surface and subsurface improvements so that storm drain construction may be permanent. Generally, the storm drain is designed to the established street grades. However, in certain sump areas, street grades may be adapted to the storm drain design because of hydraulic or other limitations controlling the drainage capabilities of the area. In such cases, the storm drain designer should estimate the minimum allowable street elevation and stipulate it in his request.

G 330 HYDROLOGY AND ALIGNMENT

The first step in the detailed design of a storm drain is the determination of runoff as outlined in Hydrologic Design (Chapter G 200). Equally important is the determination of the alignment and its many related activities as shown on Figure G 314. These functions are closely related to each other and are preferably resolved together.

G 331 SURVEY AND SUBSTRUCTURE PLAT

As soon as the field survey is received, the data is plotted on the preliminary plan for the full length of the alignment. Starting at the outlet, the street and right of way centerlines, transit lines, and property lines are plotted to scale, first for the main line, then for the laterals. (For plan layout, refer to Sections G 712 and G 732.) All surface culture (curbs, trees, etc.) shown in the survey is plotted using the Standard Symbols shown in the standard plan.

All available substructure records are searched and the substructures in the street along the alignment are plotted on the plan. The city substructure maps and utility company atlases show such utilities as water, power, gas, telephone, oil, and other conduits. These are available in the engineering district offices or the substructure section of the Utility and Estimating Division. Sewer, house connection, and storm drain information is also available from the sewer record maps and drainage maps in the respective division or district design offices. Electrolier light conduit (ELC) plans, however, are available at the Engineering Division, Bureau of Street Lighting. Traffic signal conduit (TSC) plans are available at the Signal Design Division, Bureau of Design, Department of Traffic. Fire and police signal conduit (F & PSC) plans are available at the Wire and Signal Division, Department of Public Utilities and Transportation.

The existing sewer, storm drain, and street plans along the alignment are another source of substructure information. The designer should obtain a copy of these plans and compare the substructures shown thereon with those of record. In case of doubt whether a substructure exists or not, it should be plotted, since obsolete substructures are usually abandoned in place.

Each substructure should be plotted on the plan at its given location similar to that shown on the final construction plans. The Substructure Legend indicated in Figure G 713.4 shall be used. Any rails or railbeds under the pavement should also be shown on the plan.

On certain projects, time may be saved by plotting the survey and substructure data on the ink tracings directly. Prints of the tracings are then used to lay out the design.

G 332 MAIN LINE HYDROLOGY

Before a drainage map can be prepared (Section G 241), the designer must determine the drainage area boundary cut-off points and the extent of drainage to be provided. Most City drainage projects provide service limited to a local drainage area. The local area boundary is generally set by existing ground ridges, railroad tracks, or adjoining areas served by existing storm drains.

If a sump borders a local area, the sump outflow conditions (if any) must be investigated. Generally, a sump is part of a local area if the natural outflow is to that area regardless of how the outflow occurs. Should the designer decide not to drain the sump with his project, it must at least provide capacity for future drainage of the sump.

If a drainage area which is served by an existing drain overflows into a local area, the overflow is usually not considered with the local area drainage system. This overflow should be intercepted by a xx drain. Most such overflows have a longer time of concentration than the local area time of concentration and usually do not overburden the local drain. However, under certain circumstances where 50-year frequency is used in tabling a portion of the drain, an arbitrary surface overflow from an adjacent existing drain may have to be added to the local area drain. Relief drains are usually included in the Los Angeles County Flood Control District Bond Issue Program or are added to the Master Plan of Drainage for future CIP projects.

Occasionally there is a need for an overall picture of all the drains contributing to a complex storm drain system. A Hydrologic Map fulfills this need. It consists of a plan (usually made from drainage maps) of all the contributing drains and surface flow, indicating their areas, quantity of flow for the design frequency, and time of concentration, above and below all junctions.

G 333 MAIN LINE LOCATION

Before a joint field meeting is called, the designer should set a tentative alignment and grade of the main line and laterals on the preliminary plans. This consists in determining the centerline location and vertical alignment of the conduits.

G 333.1 Plan Location: Although the general alignment of the storm drain conduit may have been chosen, its specific location in the street or proposed right of way must be determined. The main line conduit should not be located without consideration of inlet locations. Since catch basins have not been designed, their size and number and the side of the street where they are needed must be estimated. Catch basins are usually located at sumps, street intersections, or areas where runoff must be intercepted. However, where economically feasible, catch basins should be located at intersections so as to intercept all approaching flow, including dry weather flow (see Figure G 353.1).

In streets, the optimum location of the main line conduit (sized from runoff tabling) is in a clear area of conduit width plus three feet on each side. In reality, however, the area chosen is generally one with minimum substructure interference. An alignment under the existing or future curb line or parkway should be avoided. The normal location of the conduit centerline is 7 feet on either side of the street centerline, since ten-foot area of the pavement adjacent to the curb is generally used for utility substructures, an, s 'the centerline of the street for sewers. Long skew crossings of large substructures, close trenching parallel to such substructures, and trenching near buildings, retaining walls, railroads, etc., within the trench pressure area should be avoided whenever possible. In the absence of other controlling factors, the side of the street where the most catch basins or inlets are located is selected.

In rights of way, the alignment which gives minimum interference to private development of property is selected. Preferred locations are in undeveloped property along the lot line. Known slide areas or potential slide situations should be avoided whenever possible. If a slide situation is suspected, a field inspection by the Geology and Soils Engineering Section of Street Opening and Widening Division is requested.

The procedure for determining the tentative alignment is as follows: First the centerline of the main line is located and the horizontal curves are plotted (see Subsection G 333.2). Then the centerlines of the laterals are located and the angle of intersection with the main line is estimated. Finally the conduit centerline lengths are scaled from the worksheet plot plan and stationed upstream, beginning at the outlet. At a junction, the intersection of the lateral and main line centerlines is station 0+ 00 for the lateral.

G 333.2 Horizontal Curves: Changes in the direction of a storm drain alignment shall be accomplished by circular horizontal curves for conduits flowing full. Reversing curves or a series of curves in the same direction should be avoided. Vertical curves should not be located within the limits of a horizontal curve.

For reinforced concrete pipe conduits, the radius of a circular curve is generally that which conforms to pipe manufacturers' standard pipe bevel (5^o), for which the standard radii at centerline of conduit shall be:

R = 45' . . . 4' length beveled 5^o at one end.
R = 90' . . . 8' length beveled 5^o at one end.

A radius of 22.5 feet (4' length beveled 5^o both ends) should not be used unless it cannot be avoided (e.g., to clear substructures). A radius greater than 90 feet may be constructed by using a combination of standard pipe bevels and pulled joints. The pulling of joints shall be limited to 3/4" from normal closure for pipe 36" or less in diameter and to 1" from normal closure for pipe 39" or more in diameter. A concrete collar will be required if the permitted pull is exceeded.

For reinforced concrete box or arch conduits, the minimum radius of a circular curve shall be 45' at centerline of conduit.

For Corrugated Metal Pipe, the minimum radius of a horizontal curve shall be 22.5' along centerline of conduit with 4' maximum chord lengths. Fabricated connections for tangent lengths along the curve radius shall be limited to a maximum deflection of 10^O for each 4-foot length.

G 333.3 Profile Grade: The plan shows only the alignment problems. The profile must be plotted to show the vertical clearances between the substructures and the ground surface so that the storm drain grades may be established.

The profile horizontal scale should be the same as the plan horizontal scale so that the stations on the profile may be aligned as closely as possible vertically opposite those of the plan.

The procedure for determining the conduit grade is as follows: From survey elevations, plot the ground line over the centerline of the drain conduit on the profile. Next, the substructures are plotted on the profile when:

a. A substructure is crossed by the centerline of the storm drain conduit;

b. A substructure lies parallel to the drain conduit and is within the trench area; and

c. A sewer conduit lies parallel to the drain.

The depths of cover for utilities (except storm drains and sewers) plotted on the profile are estimated at:

a. 2 feet of cover for ELC, TSC, and P & FSC.

b. 2 ½ feet of cover for gas and water lines less than 12 inches in diameter.

c. 3 feet of cover for gas and water lines 12 inches in diameter or larger, oil lines, telephone and power conduits.

Storm drain, sewer, and house connection depths of cover should be taken from the construction plans or office records.

The tentative grade of the storm drain conduit is next plotted on the profile. The conduit grade and size are not considered final until the main line hydraulic and energy grade calculations have been completed.

The grade of a storm drain conduit is established principally by laying and adjusting trial grade plots on the profile. The best grade possible is the one that most nearly provides the following:

a. A straight grade approximately parallel to the average ground line with 3 to 6 feet of cover;

b. The use of judgment in minimizing substructure relocations; and

c. Adequate depth to drain laterals and sumps.

It is suggested that the grade for laterals draining sumps be plotted first, and the grade for the main line meet the lateral grade at the junction. Also, the grade plot should be done in reaches between critical points; such as sags or crests in the ground line and crossings of major substructures where a conduit grade change is most likely to occur. The conduit size calculated in the runoff tabling sheet is sufficient for use in establishing this tentative grade. In setting the conduit grade, the depth of excavation, size of conduit, and substructure interference and relocation should be considered jointly.

The minimum cover for reinforced concrete conduits subject to live loading is two feet. Where this cover cannot be obtained, the conduit should be adequately bedded (see Figure G 613) independently from the existing or proposed pavement. For conduits not subject to live loading, the conduit should have a minimum cover of one foot. For cover requirements for other types of conduits, see Section G 613.

For a given conduit size, the minimum grade shall provide a velocity of at least 5 fps when flowing half full (For pipes, see Figure G 242.2M.) For large conduits easily accessible for maintenance, the minimum grade for self cleansing velocity is less critical. For vertical curve criteria, see Subsection G 333.4.

A change in conduit grade or size is preferably located at manholes or other structures. For a change of pipe size at manholes, the soffits are joined where the change is from small to large. Inverts may be joined only when obtainable grades are so flat as to cause difficulty in attaining a minimum velocity of 5 fps. For pipe size changes from large to small, inverts are joined. Conduit grades should be adjusted to avoid substructure interference where practical. For substructure clearance information see Sections G 641 and G 642.

G 333.4 Vertical Curves: Where the pipe is to be laid on a vertical curve, the contractor shall be required to submit supplemental drawings showing his laying plans for the approval of the Engineer.

Since a concrete collar is generally not used in the design of main line storm drains, a grade change must be made by a combination of beveled pipe and pulled joints (see Subsection G 333.2). Circular curves shall be used for all vertical curves concave upward. For vertical curves concave downward, a circular curve may be used for velocities less than 25 ft./sec. For velocities greater than 25 ft./sec., a parabolic vertical curve shall be used as determined in Figure G 411.2.

The following data shall be shown on storm drain plans for all vertical circular curves which require two or more consecutive beveled joints. On the profile, the station and elevation of the P.I. of the produced pipe invert grades and the desired radius of curvature of the pipe centerline (usually 22.5', 45', or 90') are shown. On the plan, the general limits of the vertical curve by stations are shown. On the title sheet, the following note shall be placed under Notice to Contractors:

"The Contractor shall submit shop drawings of the vertical curve to the engineer for approval in accordance with Subsection 2-5.3 of the Standard Specifications as amended by Subsection 1-2 of the Standard Plan Notice to Contractors-Comprehensive."

Parabolic vertical curves shall be delineated on the plan and profile.

G 334 JOINT FIELD MEETING

The preliminary plan and profile is now sufficiently complete to determine what is involved in the project, both on the surface and underground. The designer must next initiate and conduct a joint field meeting with representatives of other agencies involved.

The purpose of the meeting is as follows:

a. To review and discuss. the nature and scope of the project;

b. To determine to what extent the agencies are involved; and

c. To determine what information these agencies must have in order to proceed with their work on the project.

Before the meeting can be called, the designer should determine in the field which agencies are involved. Such agencies may consist of the Department of Traffic, the Bureau of Right of Way and Land, the Geology and Soils Engineering Section of the Street Opening and Widening Division, and the Bureau of Public Utilities (for railroads). These agencies should be notified of the joint field meeting at least twenty-four hours in advance. Other agencies such as the Los Angeles County Flood Control District or other County departments, the State Highway Division, or adjoining cities are sent preliminary plans of the proposed construction for their review.

The designer should bring to the field the preliminary alignment and grade, the project file, the preliminary study or council file, and any other data deemed pertinent to the field meeting discussions.

When the storm drain alignment indicates excavation in major streets and state highways, the designer should request the Traffic Department to discuss the traffic control problem in the field. Considerations discussed are the following:

a. the number and width of traffic lanes which must be maintained during construction,

b. the necessity and location of detours,

c. the type of excavation (open trench, jacking, or tunneling) which is most adaptable to the situation, and,

d. other special requirements such as channelization at intersections, permits, adequate working area, etc.

See the Standard Specifications and the booklet Uniform Work Area Protection in Public Streets (Department of Public Works, City of Los Angeles) for other traffic and safety requirements.

Some considerations to be discussed in the field with the Right of Way representative are the adequacy, probable availability, comparative cost, and alternate locations of the proposed right of way and construction easement. The existing improvements affected by the construction within the proposed right of way are also discussed.

In hillside areas, near embankments, or in any area where unstable or potential slide situations may exist along the alignment, the designer shall request the Geology and Soils Engineering Section of the Street Opening and Widening Division to investigate the area in the field. Preventive procedures to be determined are as follows:

a. the selection of a possible alternate alignment,

b. the advantages of jacking, tunneling, or open trench excavation (Section G 140),

c. the requirement of tight sheeting to maintain lateral support.

d. the requirement of special compaction for backfill to reduce the probability of lubricating rock strata or soil masses,

e. the location of test borings at key points to better determine the stability of the soil and the method of backfill.

If further investigation is indicated, the designer should request a report with recommendations on the geological and soil conditions of the area.

The storm drain alignment sometimes involves railroad signals or the temporary interruption of railroad service. In such instances, the designer should confer with a representative of the railroad to discuss their requirements.

As soon as possible after the joint field meeting, the designer should write a summary of the meeting for file. The memorandum should list those who attended the meeting, the location of the meeting site, the date, what was discussed, what decisions were reached, and what agreements were made. A copy of the memorandum should be sent to the heads of departments involved in the project. If an agreement was made at the meeting, all conditions of the agreement should be included in the report.

G 335 MAIN LINE ADJUSTMENT AND RIGHT OF WAY SKETCH

Based on the decisions reached at the joint field meeting, the designer should set the final alignment and rights of way required for the project. A right of way sketch is then prepared and two copies are transmitted with the request (Figure G 335) to the Street Opening and Widening Division and one copy to Projects Control Division. The design office acquires a right of way number from the Bureau of Right of Way and Land and gives both numbers (W.O. and R/W) on the sketch. The Street Opening and Widening Division in turn prepares the preliminary right of way map and requests the Bureau of Right of Way and Land to make a title search on the property. If a title search for prior rights on an existing substructure is deemed advisable, this request should be transmitted with the sketch.

The right of way sketch is usually traced from a District Map on an ozalid transparency. Pencil or ink may be used. The size and location of the rights of way should be dimensioned thereon, and the limits should be outlined in red pencil. If more detail is required, a blow-up of the parcel is drawn. It is important that the type, legal description, and map book reference of the parcel be indicated on the sketch (Figure G 335A). The use of a drainage easement for covered conduit or open channel should be specified on the sketch.

The size of the right of way selected should be in accordance with the standards given in Figure G 122. However, special structures such as inlets, outlets, pump stations, and storage basins have right of way requirements that vary according to field conditions and the drainage installations.

In many instances, the acquisition of inadequate rights of way, especially at inlet and outlet structures, has appreciably increased the cost of maintenance. At inlet structures, the right of way should include all erosion protection measures and slope embankments. It should extend a sufficient distance upstream for the installation of debris protection if required. At outlet structures, especially for high velocity flow, the right of way should include all bank protection and extend a distance downstream from the velocity breaker. Wherever heavy debris accumulation, erosion, or flapgates require constant maintenance, right of way for easy vehicular access to the structures should be provided.

Should the alignment be changed or outlet or inlet structures be relocated as a result of the field meeting discussions, the designer shall request the additional field work required as soon as the realignment is selected.

G 336 TEST BORINGS

All storm drain projects extending 500 feet or more in length should have two or more test borings. All test borings are made by the City Bureau of Standards: Based on specific knowledge of the area, the designer 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 test 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 test 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 designer 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 harmful 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. Section G 160, Soil Mechanics Nomenclature, is provided to help the engineer comprehend the soil reports. 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 is shown on the plans as shown on Figure G 713.4A. These logs shall be taken verbatim from the soil report.

G 336.1 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 designer 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. Storm drain stationing 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 storm drain invert.

b. When ground water is encountered, at least six feet below the proposed storm drain 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 designer shall use closer spacing, however, when in his judgment 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 (see the first sentence, Section G 336).

G 336.2 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 (see Figure G 713.4A).

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 ground water 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 Figure G 336.2. Chemical analysis of either ground water or soil sample for 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.

Some means of detecting a soil or water detrimental to concrete are as follows:

1. Deterioration of existing concrete structures in the area,

2. Types of concrete used for existing structures as shown on the plans and specifications,

3. Infiltration of salt water into the ground water along seashore areas.

4. Previous soil test records.

SULFATE CONCENTRATION HARMFUL TO CONCRETE

% Water-soluble sulfate (as SO_4) in soil samples	p.p.m. sulfate(as SO_4) in water samples	Relative degree of attack on concrete	Suggested Type of resistant concrete
to 0.l0	to 150	Negligible	--
0. l0 to 0.20	150 to l000	Positive	Type II
0.20 to 0.50	l000 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.

Figure G336.2

It is not necessary to call for Type II cement on the plans, since the Standard Specifications for Public Works Construction require Type II cement for all storm drain structures. Therefore, only Type V cement is specified on the plans when a soil or water sample test so indicates (Figure G 336.2).

G 337 MAIN LINE CENTERLINE CALCULATIONS

Before centerline calculations are made, cross sections, survey data, and street grades are plotted and the main line structures are located on the preliminary plan and profile.

In streets, cross sections are required to show the close proximity or depth of substructures relative to the proposed conduit. These sections are most often plotted where side clearance must be determined, since the profile shows the vertical clearances- of substructures which cross the centerline of the drain. In rights of way, cross sections are required to show the ground lines of sumps or watercourses relative to the proposed conduit. Cross sections are chosen at sags or crests and at regular intervals of 25 or 50 feet. These cross sections will be used to determine the final ground line over the conduit, which must provide for local drainage and adequate cover over the conduit.

G 337.1 Location of Structures: In order to calculate the hydraulic losses of the main line and laterals, the structures must first be selected, located along the alignment, and plotted on the preliminary plan and profile. Where realignment is required, as discussed in the joint field meeting, it must be done before the structures are located. These structures generally consist of manholes, junctions, transitions, and inlet and outlet structures. No detailed design of the structures is required at this time.

The type of manhole selected is based on the type of conduit used, as given in Section G 621. Manholes should be provided wherever access is required for maintenance purposes. A junction or transition should not be located within an intersection, but at a location which will least interfere with traffic.

Manholes shall generally be provided for all junctions of main line and laterals, at spaced intervals along the conduit, and near intersections for access to catch basin connections. The approximate spacing of manholes along a conduit shall be as follows:

300' for pipes up to 24" I.D.
400' for pipes 27" I.D. or larger.
500' for box or arch.

G 337.2 Calculations and Stations: The lengths of the main line and lateral conduit centerlines are calculated and stationed on the plan. This stationing is also used to advantage in the hydraulic calculations by tying in the gradient elevation with the conduit location. The distances and angles used are those measured by field survey in preference to recorded data. All distances used and stations calculated are horizontal. See Section G 910 for the analysis of traverses by the computer.

The procedure to station the centerline of conduit is as follows:

1. Tie the main line conduit centerlines to transit line or street centerline.

2. Calculate and/or tie all curve P.I.'s and angle points. Set or calculate all curve deflection angles (Δ) and radii (R). (See Subsection G 732.1.)

3. Calculate tangents (T) and lengths (L) of all curves, and plot curves on plan to check the alignment clearance to substructures. (Use Figure G 337.2.)

4. Determine lengths between curves and/or angle points.

5. Starting at the outlet or centerline intersection (station 0 + 00), add all lengths (items 3 and 4), stationing upstream along the conduit centerline, and station all angle points and curve BC's and EC's.

6. Calculate distances to centerline of manhole and ends of box transition, and station same.

7. Calculate distances to intersection of centerlines at junctions and station junctions with an equation; e.g., 1 + 82.69 Line A = 0 + 00 Line C (A = main line, C = lateral).

8. Repeat items 1 through 6 for laterals, starting at 0 + 00 at the junction.

9. Delineate all stations on main line and lateral profiles. See Subsection G 732.1 for Survey ties.

G 337.3 Preliminary Right of Way Map: A copy of the preliminary right of way map is transmitted to the design office by the Street Opening and Widening Division. This map should reproduce the data given on the right of way sketch (Section G 335). The designer shall check that the rights of way are correct in size, location, and proposed usage. If errors are found, the map is corrected and returned to the Street Opening and Widening Division. Otherwise, no further action is taken at this time.

G 338 LAYOUT ON TRACINGS

The layout of the main line and lateral centerlines on the final plan tracings may be started, provided the alignment is final and the centerline calculations have been completed and checked. The drafting of the final plans can thus progress with the design, thereby avoiding undue delay at the end of the design.

Only the plan layout should be drawn, excluding the construction notes. Prints of these layouts should be used to complete the design, plot the profile, and position the construction notes. (See Section G 730.)

G 339 SUBSTRUCTURE EXCAVATIONS

Almost without exception, streets in which storm drains are proposed to be located will have substructures that interfere. In design, every attempt is made to locate the proposed drain crossings over or under existing substructures; when this is impossible, the interfering substructures must be relocated. Knowledge of the exact location of substructures, which very often requires their uncovering, is therefore necessary. The designer is responsible for requesting the excavation of interfering substructures as soon as the horizontal and vertical alignments are established.

Substructures in streets generally consist of pipe lines or similar conduits owned by the City, the County, or agencies under franchise with the City. Existing City and County storm drains and sewers usually do not have to be uncovered to determine their location. The plans and profiles are adequate for positive location when supplemented by the project survey. The booklet Substructure Damage Prevention, published by the Los Angeles Substructure Committee, contains the names and telephone numbers of agencies which own substructures in the area

The preliminary study plan and profile shows substructures, such as utility and oil lines, plotted at an estimated depth of cover. Any such substructure, 6-inch diameter or over (and 4" gas line), which is located within 12 inches of the proposed storm drain should be uncovered and the elevations of the top and the bottom determined. In the Central District, this is requested by sending a memorandum and location sketch (Figure G 339) to the substructure section of the Utility and Estimating Division, which makes all necessary arrangements. In the other Engineering Districts, the designer requests the excavation directly from the substructure owner, and makes all necessary arrangements to survey the substructure. A no-fee excavation permit is usually issued to the owner. For relocation of interfering substructures, see Subsection G 364.1.

G 340 MAIN LINE HYDRAULICS

The hydraulics of the main line and laterals are next calculated and the conduits are adjusted until a hydraulic balance is achieved. A hydraulic balance is the most economical combination of conduit and appurtenances that best meets the project requirements and satisfies the general design criteria given in Section G 313. Hydraulic balance is achieved by the summation of the hydraulic head losses of conduit and structures by trial and error calculations and by adjustment of conduit size and grade to meet existing or required water surface elevations.

G 341 DESIGN PROCEDURE

Before the hydraulic calculations are started, the preliminary plan and profile should be reviewed to ascertain that all the required structures are shown and properly stationed. The design procedure is then as follows:

1. All hydraulic controls along the alignment are established (see Section G 342). If the control is at a main line upstream inlet, the hydraulic gradient is the water surface elevation minus the enhance loss, minus the difference in velocity head. If the control is at the outlet, the water surface is the outlet conduit hydraulic gradient.

2. For the first reach under consideration, the head losses are calculated progressively as shown in Section G 343. The first reach should be taken from a control to the first junction (or transition) structure, or to the first conduit grade break.

3. The head losses are tabled and the energy gradient (E.G.) and the hydraulic gradient (H.G.) are calculated as shown in the Sample Calculations (Section G 344). The head losses are added to the E.G. when working upstream or subtracted from the E.G. when working downstream.

4. The hydraulic gradient is next plotted on the preliminary profile and evaluated in relation to the conduit and ground line. The H.G. slope should approximately parallel the average existing ground slope and be a minimum of 3 inches above the conduit soffit. This may be accomplished by adjustment of the conduit size.

5. Repeat steps 2, 3, and 4 above for each subsequent reach.

G 342 HYDRAULIC CONTROLS

A hydraulic control is a set water surface elevation from which the hydraulic calculations are begun. A control may be located at the inlet, the outlet, or intermediate points along the alignment.

A control at the inlet may be due to a predetermined water surface elevation in a storage basin or at catch basins. An inlet in a watercourse may have a maximum water surface elevation necessary to prevent upstream flooding from backwater. If the upstream end of a proposed drain accommodates an existing or future drain, the hydraulic gradient elevation required for the existing or future drain may be the control Whenever more than one control condition exists at the inlet, the more restrictive condition should prevail.

A control at the outlet may be the hydraulic gradient of an existing drains or the water surface of a channel or river into which the flow is discharged. The hydraulic gradient elevation of an existing drain should be calculated at its peak flow. A predetermined water surface elevation in a retention basin may be a control at the outlet. When the outlet is to the harbor, a water surface elevation of 2.74 feet (Mean Higher High Water, Figure G 342) above mean sea level is used as the control. When the outlet is on the beach, the ocean surface usually does not control the outlet hydraulic gradient; the invert is placed above elevation 4.0 feet (Bur. of Eng. Datum).

At junctions, the head required by a lateral may affect the maximum elevation of the main line hydraulic gradient. A major grade change in the ground line over the conduit may require a change in conduit size and hydraulic gradient. These conditions limit the vertical location of the H.G. sufficiently so that they may act as a control.

G 343 HEAD LOSSES

The head losses for storm drains are computed for conduits, manholes, junctions, transitions, entrances, and outlets.

The roughness coefficient used in design for flow in streets or storm drain conduits shall be Manning's "n" values shown in Figure G 343.

G 343.1 Conduits: The energy losses in conduits are friction and curve losses. The friction head loss (h_f) for a length of conduit (L) on friction slope (s_f) is:

$$h_f = L \times S_f \quad \text{where } S_f = \left(\frac{Q}{K}\right)^2$$

(see Figure G 612)

The head loss due to curves (h_b) for conduits under pressure is:

$$h_b = .002 \times \Delta \times h_v$$

where Δ is the angle of curvature in degrees and h_v is the velocity head in feet.

The head loss due to an angle point is:

$$h_a = .0033 \times \Delta \times h_v$$

(see Section G 333.2)

G 343.2 Manholes: The head loss at manholes (h_m) for conduits under pressure is as follows:

1. For M.H. "AX," and M.H. "BX" when used with arches, $h_m = .05 \times h_{vo}$

where h_{vo} is the outlet velocity head in feet. This loss occurs in addition to transition or junction head losses, and is omitted for pipe used as box alternate.

2. For M.H. "EZ," $h_m = .10 \times h_{vo}$

plus the junction or transition loss.

3. For M.H. "BX," when used on a rectangular conduit, the head loss is negligible.
4. For M.H. "JM," see *Junctions*.

G 343.3 Junctions: The hydraulic analysis of junctions (J.S. "B," J.S. "C," and M.H. "JM") requires the evaluation of pressures and momentums at various locations in the junction. The head loss at a junction (h_j) is computed as follows:

$$h_j = \Delta Y + h_{v_1} - h_{v_2}$$

where h_v is the velocity head at their respective points and ΔY is calculated as shown in Appendix C (Office Standard No. 115), attached herein.

In the hydraulic calculations of junctions, the following criteria shall apply:

1. The sum of the main line inflow (Q_1) and the lateral inflows (Q_3 and Q_4) must be adjusted to equal the main line outflow (Q_2) at its combined time of concentration (t_{cx}).

$$Q_1' = A_1(F_{RO})\,BPRR_{t_{cx}}$$

$$Q_3' = A_3(F_{RO})\,BPRR_{t_{cx}} \text{ etc., so that}$$

$$Q_1' + Q_3' + Q_4' = Q_2$$

When F_{RO} is the same for all areas, then

$$Q_1' = Q_2\left(\frac{A_1}{A_2}\right) \text{and } \; Q_3' = Q_2 - Q_1'$$

2. A junction head loss shall be considered negligible for a catch basin inflow of 10% or less of the main line outflow. The catch basin inflow must be adjusted to the main line outflow t_{cx} before a comparison is made. Exceptions to the above for which a junction head loss should be calculated are as follows:

(a) An inflow of 30 cfs and larger, even if less than 10%.

(b) Two inflows into the same junction, each less than 10%, but greater than 10% when combined.

(c) An inflow into a main line transition.

ROUGHNESS COEFFICIENTS

PIPE, BOX, OR ARCH:	Manning's "n"
Transite (asbestos cement) Pipe	.013
Reinforced Concrete Pipe	.013
Reinforced Concrete Box or Arch (cast in place)	.013
Corrugated Metal Pipe	.0225
Corrugated Aluminum Pipe	.0225
Corrugated Metal Pipe (paved invert)*	.020
Corrugated Metal Multi-plate Conduit (60″ to 96″)	.035
PAVED STREET:	.013

*Paved ⅓ of wetted perimeter—pipe flowing full

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Figure G 343

3. The Hydraulic Gradient for a lateral or catch basin inflow at a junction shall be the same as the main line Hydraulic Gradient where the lateral joins the upstream end of the main line junction. (Point "O" on plan, page 28, Office Standard No. 115.) The Hydraulic Gradient at Point "O" (HG_o) may be determined (neglecting friction) as follows:

$$HG_O = HG_1 + h_{v_1} - h_{v_1}{}'$$

(See calculation, Figure G 344A)

For hydraulic calculations of a lateral upstream of the junction, the lateral velocity head, calculated from a Q based on the lateral t_C , is added to the HG_o to get the lateral EG.

For geometric design of junctions, see Section G 622.

G 343.4 Transitions: The head loss at transitions (h,) for pressure flow is computed as shown in Figure G 343.4. If the rate of contraction or expansion is different for the side walls than for the top and floor slabs, the head loss is based on the condition which produces the greater loss. If the rate of contraction or expansion is not symmetrical on both side walls, the head loss is based on ½ the total expansion. Where a conduit is transitioned to clear an obstruction and then returns to a normal section, a transition head loss shall be attributed to both ends, upstream and downstream. Where a transition coincides with a junction, the transition head loss is taken into account with the junction head loss. For geometric design, see Section G 623.

G 343.5 Entrances and Outlets (Not at Junctions): The head loss at the entrance (h_e) to pipe or box with slightly rounded inlet of 3-inch to Finch radius is:

$$h_e = 0.2 \times h_v$$

The head loss at the outlet (h_O) of pipe or box is equal to the change in velocity head.

The head loss due to flapgates is negligible.

The head loss at an inlet with a protection barrier should be calculated from an inlet velocity based on the net clear inlet area. For geometric design of inlets and outlets, see Subsections G 631.1 and G 632.1.

G 343.6 Sudden Expansion or Contraction: The head loss due to a sudden expansion (h_x) of a conduit is:

$$h_x = K_2 + h_v$$

(K2 from Table) *

The head loss due to a sudden contraction (h›) of a conduit is:

$$h_c = K_3 + h_v$$

(K_3 from Table)*

These losses are applicable when a concrete collar joins pipes of unequal diameter. A sudden contraction without a transition should be avoided.

G 343.7 Flow Separation: Occasionally, such as with relief drains, there is need for the separation of flow. Little information is available on the allocation of flow quantities and the determination of head losses for flow separations in storm drains. However, the following general information is offered:

1. For major flow separations (where the flow quantity is critical to flood conditions), a splitter wall is recommended, splitting the flow proportionally to the area and designing for equal energy and hydraulic gradients in both flows.

2. For major flow separations, the following volumes from the Transactions of the Munich Hydraulic Institute should be used as a guide: Loss in 90° Pipe Branches by Vogel, Volume 2; Loss in Oblique-Angled Pipe Branches by Petermann, Volume 3; Loss in 45° Pipe Branches with Curves by Kinnie, Volume 4.

District offices should consult the Storm Drain Design Division for the design of flow separation structures.

G 344 SAMPLE CALCULATIONS

The Summary of Hydraulic Calculations (Figure G 344) is a compilation of the head losses to determine the energy and hydraulic gradient elevations. The Sample Head Loss Calculations (Figure G 344A) are examples of the determination of the various head losses. The calculations are made on the storm drain sketched on Figure G 344 (taken from Figure G 241.1).

The values for columns 1, 2, 3, 9, and 10 (Figure G 344) are taken from the preliminary plan and profile. Columns 5 and 7 are taken from Figure G 612. Column 4 is from the runoff tabling sheet. Columns 6 and 8 are calculated from columns 4, 5, and 7. Columns 11 to 17 (inclusive) are calculated as shown in Section G 343.

Kingss Handbook, 5th Edition (1963) pp. 6-55 to d-57.

The tabling sequence for Figure G 344 is as follows:

(a) Starting at the control (see Section G 342), list the data for the proposed 48" conduit on line 1, columns 1 to 7.

(b) List the control HG on line 1A, column 20. Add h, to the HG to get EG and list on line 1A, columns 18 and 19.

(c) List the data for the next structure (J.S. at 4 + 00) on lines 3 and 4, columns 1 to 7. Calculate S. (for reach 0 + 00 to 4 + 00) and list with L (and A, if any) on line 2, columns 8 to 10. Calculate the head losses and list on line 2, columns 11 and 12. List ΣH_L on line 2,. column 17. Notice that the friction head loss is taken to the junction station to eliminate-friction loss in the junction head loss calculation.

(d) Add ΣH_L (line 2) to the EG (line 1A) and list the new EG in column 18, line 2A. Calculate hr and list in column 19, line 2A. Subtract hr from EG and list in column 20, line 2A. Notice that the head losses are added to the EG in this case because the calculations proceed upstream.

(e) Calculate the junction and manhole head losses at 4 + 00 and list on line 3 in columns 13, 14, 15, 17. Calculate EG, hv, and HG and list on line 3A as shown in (d) above.

(f) Repeat (c) to (e) above for each structure to completion of calculations.

G 345 MAIN LINE SLOPE

After the conduit size and depth have been determined by the hydraulic calculations, the conduit invert slopes are calculated and listed on the preliminary profile. The locations of elevations- at structures are indicated on the standard plans.

The slope calculations are carried to six decimal places and listed on the profile to five decimal places. The invert elevations are calculated to the nearest thousandth of a foot and listed on the profile to the nearest hundredth of a foot. The calculations are made in reaches between grade changes.

Only the main line and laterals are given slopes and elevations on the profile. Catch basin connections show only elevations at both ends of pipe and at grade changes in between (see Section G 742).

G 350 CATCH BASIN DESIGN

In city streets, the runoff is collected into catch basins at sumps, at intersections, or at spaced intervals. Economics and limiting physical conditions control the number- and length of basins required to intercept a given quantity of water. The design of catch basins consists in determining the quantity of flow to the basins, locating and sizing the basins, and connecting the basins to the main line.

G 351 HYDROLOGY

The hydrology for catch basins determines the quantity and location of runoff to be intercepted. A catch basin drainage map is prepared, the path of street flow is routed, and the Q's at the basins are determined.

G 351.1 Drainage Map and Runoff: To determine the Q from the contributing area at each basin (or group of basins), the F_{RO}, BPRR, and acreage of that area must be individually calculated.

First, a Catch Basin Drainage Area Map (Figure G 351.1) is prepared from a print of the Main Line Drainage Area Map. The outlines of the areas contributing to the basin (or basins) on each side of the street are shown and the acreage is converted to A_e (Subsection G 241.5).

The Q to each basin (or basins) must be based on the peak runoff of each area produced by the local t_C of that area. This results in a Q at the basin larger than the Q tabled to the main line for the same area, because of the shorter t_C for the local area. The runoff factor (F_{RO}) is based on the Isohyetal for each area, which can be interpolated to the center of the area from the map. The runoff (Q) for each basin (or group of basins) is calculated as shown in the table below the map (Figure G 351.1) as follows:

1. From the Catch Basin Drainage Map, list the area numbers and their A, for each basin (or basins) .
2. From the map, record the Isohyetal as indicated above, and calculate the Rainfall Rate

(RFR) by the frequency factor given in the table on Figure G 241.1A and list.

3. Enter Figure G 242.2F to K with the RFR, read the Runoff Factor (F_{RO}) for the 100% impervious classification, and list.

4. List the street gutter slope and length, and determine the t_C for the initial 700 feet from Figure G 242.2A to D. For flow length (L) other than 700 feet, multiply the above t_C by

$$\left(\frac{L}{700}\right)^{1/2}$$

(see Subsection G 242.2, No. 3c). List t_C .

5. Enter Figure G 242.2L with the t_C , read the Base Peas Runoff Rate (BPRR), and list.

6. Calculate the runoff (Q = A_e x F_{RO} x BPRR) and list the Q for each catch basin area.

G 351.2 Routing Street Flow: It is important that the flow in the street be accurately determined, because the catch basin capacity charts are based on the resulting depth of flow. The factor which must be carefully analyzed are the street characteristics and the quantity of flow.

To determine the gutter slope, street cross sections are taken at the upstream end of the catch basin and at 50 or 100 feet farther upstream. This slope should reflect the street grade and not a local hump or hole in the gutter. The street flow charts (Office Standards No. 94 and No. 118) should not be used for catch basin design. The street cross sections at the upstream end of the catch basin should be drawn to scale from Survey Data and the depth of flow should be calculated for the given Q as shown in Figure G 232.

Although the Q for the area contributing to a catch basin (or group of catch basins) is calculated for each side of the street, all the water may not reach the basin. There may be an overflow to or from an adjacent area, cross flow over the crown, or a split of flow at intersections. The street flow routing must therefore begin at the uppermost area and proceed downstream along its natural path so it may be progressively routed for both sides of the street. If an overflow adds a considerable quantity of water to the local area Q, the combined Q should be computed as a main line junction (see Subsection G 242.2, No. 7).

In routing street flow, the depth of flow must he determined on both sides of the street at the same location. This determines whether the flows remain on their respective sides of the street, flow over the crown, or combine to occupy the entire street. This also applies to catch basins in series if, in the judgment of the designer, the basins are spaced far enough apart to allow the flow to cross over.

G 352 CATCH BASINS

The designer must select the type of catch basin that best applies to local conditions. He must also determine the location and number of basins required to intercept the flow. City practice on these requirements is discussed in the following sections.

G 352.1 Types and Uses: The three basic types of catch basins are the side opening, the grating, and a combination of both. The types of basins used by the City and their recommended applications are summarized in Figure G 352.1.

Side-opening basins are preferred to intercept street flows. They are particularly recommended in sumps.

The use of grating basins is generally avoided when possible because they tend to clog with debris. This is especially true in sumps. When one must be used, such as at an alley sump, one additional grating should be added to the calculated size required. A grating basin is more efficient and economical than a side opening basin on street slopes greater than 5% and on streets with low crowns.

The combination grating and side opening basin has special applications. The main application is to clear debris from the grating. The sweeper basin (C.B. No. 44) is located upstream of a series of grating basins to intercept debris.

When a storm drain is not constructed upstream to its ultimate length, additional catch basins are required to intercept street flow to the capacity of the drain, unless the completion of the drain upstream is imminent.

G 352.2 Location: It was previously stated that street flow is intercepted at sumps, at intersections, and at spaced intervals. To do this, catch basins must be located in the street. All catch basins shall be placed at their permanent location (location of ultimate improvement) and must fit in with existing improvements. The number and size of basins used on each side of the street depends on the street slope and the amount of flow on each side.

Generally, the deeper the flow at a basin, the better the interception. The efficiency of a basin per foot of length becomes less as the length increases. Conversely, the efficiency per foot of basin increases as its length is reduced. Two or more basins of 20 feet or less in length spaced 8 feet apart (one pipe length) are preferred over a single basin excessively long or basins of 28 feet or more in length. Also a basin is more efficient if a small amount of runoff (10% or 1 cfs) is allowed to pass.

However, in sumps where the water ponds, a single long basin on each side of the street is generally more economical than a number of basins in series. The basin must be located at the low point of the gutter flow line to provide total drainage. If an existing driveway interferes, the flow line should be modified where possible to provide a low point clear of the driveway. When a street grade decreases sharply just prior to a sump, silt and debris are deposited in the street due to a decrease in velocity. An additional small basin should be located to intercept low flow before the debris is deposited.

At intersections, the street flow should be intercepted before it reaches the pedestrian crosswalks (3' to 5' upstream of the curb B.C.) This curb area may be congested by existing facilities. Within economic limits, the designer should try to locate the catch basins with minimum interference with these facilities. When this cannot be done, some facilities must be relocated. The more important facilities in the curb return area are shown below in the order of their priority:

1. Traffic signals and warning signs
2. Driveways
3. Catch basins and culverts
4. Electroliers
5. Power or telephone poles
6. Fire hydrants

The basic considerations of this priority listing are location restrictions, traffic safety, and relocation cost. Relocation of the facilities with lesser priority should be considered first.

When intersections are more than 600 feet apart, catch basins should be provided mid-block with a maximum spacing of 600 feet. Catch basins may be omitted only when the street flow does not exceed a width of 6 feet. Basins should also be located upstream of the high side of a superelevation transition to prevent flow across the pavement. When railroad tracks cross a street, the street flow should be intercepted by a catch basin just prior to the tracks, because the surface flow cannot be contained within the street at these crossings. Catch basins shall also be provided to eliminate cross gutters.

G 352.3 Capacity Charts: The capacity of a catch basin is the amount of flow it is able to intercept under a given street configuration and flow characteristics. Appendix B (Office Standard No. 108) attached herein provides sample problems and design capacity charts for the design of catch basins. These charts apply to the following types of catch basins:

a. The X-5 type curb opening (C.B. Nos. 45 and 46) as shown on charts LL-7 to LL-10 inclusive.

b. The C.B. Nos. 38, 39, and 40 type curb openings as shown on charts LL-12 to LL-15 inclusive.

c. The Pasadena type curb opening (C.B. No. 47) as shown on charts LL-16 and LL-17.

d. The grating opening (C.B. No. 37) with different combinations of gratings as shown on charts LL-18 to LL-25 inclusive.

The street configurations used in these studies are shown on the quoted figures and charts. Results acceptable to the City may be acquired for other street configurations by adjusting the depth of flow "D" at the basin. Attention is called to Appendix B, Office Standard No. 108, Supplemental Instruction No. 1 in reference to total interception and interception for depths below 0.4 feet (for side opening catch basins) and Supplemental Instruction No. 2 in reference to design policy for catch basins and connector pipes.

To determine the capacity of combination catch basins, only the grating must be considered, since experimental data is not available for this type of basin. For catch basins No. 36 and No. 44, the total capacity of the basin shall be limited to the maximum capacity of the grating (or combination of gratings) as determined by the grating capacity charts. This limitation is based on the theory that only the prism of water directly over the grating (or gratings) is considered available for interception.

G 353 CONNECTOR PIPES

To complete the design of a catch basin system, the connector pipes to the main line must be designed. This consists in determining the alignment of the connector pipe, calculating its size and depth, and plotting its grade.

The suggested procedure for the design of catch basin connector pipes is as follows:

1. Determine and plot the connector pipe alignment on the preliminary plan.
2. Plot catch basin, main line conduit, substructures, and ground line along centerline of connector pipe alignment in profile.
3. Determine the connector pipe size and catch basin depth by hydraulic calculations and plot connector pipe in profile (2) above. Minimum connector pipe size is 18". See Office Standard No. 108 for catch basin depth requirements.
4. Check connector pipe profile for clearance from substructures.

G 353.1 Alignment: Generally, the most economical alignment is the shortest and straightest connection intersecting the main line at an acceptable angle with the direction of flow. (See Figure G 622.) For one or two catch basins in an area clear of substructures, the connector pipe alignment is usually straight into the main line except where the length is excessive and a short lateral is required. For a large group of basins, the most effective connection is a lateral to the main line, especially if a future extension is planned along the alignment of the lateral. The connection of catch basins to each other in series or on curves is generally not recommended. (See typical connection layouts on Figure G 353.1.)

The alignment of connector pipes may require many trial layouts and cost comparisons. Some factors which affect the cost of catch basin connections are:

l. The length, size, and depth of pipe used
2. The depth and reinforcement of catch basins
3. The number of manholes or junctions required
4. The relocation of existing utilities
5. The acquisition of drainage easements

G 353.2 Hydraulic Charts: Parts VII and VIII of Appendix B (Office Standard No. 108) attached herein provide sample problems and charts for the solution of hydraulic calculations (full flow and inlet control) of catch basin connector pipes. For full flow, the control is at the main line hydraulic gradient. For part full flow, the control is at the catch basin, 6 inches below the gutter flow line. The minimum pipe size for connector pipes is 18 inches.

G 353.3 Profile and Slope: All catch basin connections shall be plotted to the standard profile scale. Each connector pipe profile shall extend from the basin to the main line or lateral, showing the ground line and substructures at centerline of pipe, giving elevations and pipe size and length. These profiles are utilized to determine the pipe slope or grade changes necessary to clear substructures, to show the required construction such as concrete collars or special bedding, and to provide elevations for catch basins and junctions. For connector pipe lengths over 25 feet between grade breaks, the slope is shown on the catch basin profile.

The minimum grade for connector pipes is 0.015 and the minimum velocity is 5 fps. If a connector pipe grade must be changed to miss interfering substructures, the depth of the connector pipe and catch basin may be adjusted and a new connector pipe size calculated, the alignment may be changed, or a break in the connector pipe grade may be made.

G 360 PRELIMINARY PLAN

Sufficient design data are now available to complete the preliminary plan and determine which facilities are affected by the proposed construction. The design of these facilities by other offices should be requested before structures and other construction details are designed. The design details are next completed, the right of way requirements are reviewed, and the acquisition of right of way is requested.

G 361 SKETCH FOR STRUCTURAL DESIGN

Certain special structures (Section G 630) require individual structural design by the Bridge and Structural Design Division. Such structures usually include reinforced concrete box conduits and transitions, inlet and outlet structures, and modifications of standard structures. Before structural design can be requested, the storm drain designer must prepare a sketch detailing the geometry of the structure.

The geometric design of these structures is generally based on hydraulic requirements such as the control of flow at an outlet, the head loss at a transition, and others. Each structure is individually designed to meet the needs of a specific application. The designer should refer to the applicable section (Chapter G 600) for a discussion on requirements and the geometry of these structures.

A geometric sketch should show enough dimensions, elevations, and angles to describe completely the size and shape of the structure in plan, profile, and sections. Contours, ground lines, and ties sufficient to locate the structure vertically and horizontally should also be shown. Additional structures such as protection barriers and fencing should be indicated, if required. The sketch should be drawn on transparency paper to natural scales (1/4" = 1' or 1/2" = 1') for structural detailing.

Upon completion of the geometric sketches, the designer requests structural design from the Bridge and Structural Design Division by memo. Two prints of the sketches and one print of the preliminary plan and profile are transmitted with the request. Other pertinent data such as test borings and geological reports (if available) should also be included.

G 362 DESIGN BY OTHER OFFICES

Most storm drain projects require some work by other design offices. Any City or County sewer relocation (other than house connections), street remodeling, and traffic or street light relocations are designed by their respective city design offices. As soon as the required information is available, the designer should request the appropriate design offices to prepare the necessary construction plans for the work indicated above. A copy of the preliminary plan and profile showing the proposed construction in the area and any other pertinent data should be transmitted with the request. (For structural design request, see Section G 361.)

A copy of the preliminary plan and profile is also sent to other agencies whose facilities or rights of way are affected by the design. A letter is transmitted requesting their review and comments. Agencies usually affected are the State Division of Highways, the Los Angeles County Flood Control District, or the Corps of Engineers, United States Army. For acquisition procedure of permits, see Sections G 127 and G 128.

G 363 STRUCTURES AND DETAILS

The data needed to delineate the construction of structures and other items are determined and noted or detailed for duplication on the final plan. Design criteria, uses, and other requirements for these structures are given in Storm Drain Structures (Chapter G 600).

G 363.1 Standard Structures: A standard structure is one of common storm drain usage which is delineated by a standard plan. The designer must determine the lengths, elevations, angles, and other construction data called for by the standard plan notes.

Certain structures such as junctions (Figure G 622) and transitions (Figure G 623) should be drawn to a large scale to determine their dimensions properly. The resulting data are noted on the preliminary plan and profile, but the drawings are not shown on the final plans if the structure is constructed according to standard plan. However, if a structure proposes a modification of the standard plan, the modification should be completely detailed for duplication on the final plans.

G 363.2 Details and Other Construction: Other structures, such as debris barriers and subdrains, which do not require structural design by the Bridge and Structural Design Division and which are not covered by a standard plan, must be designed and drawn in detail for construction.

The structure is shown on the final plan and referenced to a Detail. The detail must show all the information necessary to size, fabricate, locate, install, or construct the structure, and must be drawn to scale in final form to be duplicated on the final construction plans. One detail may be used for two or more similar structures if practical.

Special construction methods not covered by the Standard Specifications require details or construction notes. Examples of these methods are jacking and special compaction or backfill. The designer is referred to Excavation and Backfill (Section G 140).

After having determined the need for special construction, the designer should indicate the type and limits of this construction on the plan or profile and draw the necessary construction details or notes for duplication on the final plans. When structural design is required (as it is in tunneling), the data is transmitted to the Bridge and Structural Design Division as discussed in Section G 361.

Few projects require special provisions to supplement the final plans. In such a case, any instructions or controls required for construction should be noted on the plans. For extensive projects requiring special provisions, the designer is expected to write a preliminary draft of the technical provisions describing the intent and controls of the special construction. The specification section of Utility and Estimating Division will prepare the final special provisions, but they should make no technical determinations.

Construction items such as the disposal of interfering substructures or surface improvements, traffic control during construction, resurfacing, access roads, fencing, etc., must be determined and noted. The notes for relocations, removals, abandonments, supports, and reconstructions should include the following information:

a. size, type, or use of the item
b. location of each item and name of owner
c. disposition of each item and by whom handled.

The requirements for the control of traffic during construction generally consist of the following:

a. access to private property
b. detours and related construction
c. the number and size of traffic lanes
d. the names of the streets closed to traffic
e. the time limitations of traffic control
f. adequate working space for construction.

These requirements may be drawn as a "plan" or noted on the final plans. (See also the Standard Specifications for Public Works Construction.)

All resurfacing should be shown on the Key Map. The resurfacing listed is the pavement to be constructed and is not necessarily the existing pavement. See Resurfacing (Section G 649).

Access roads in right of way should be designed for alignment, grade, geometric cross-section, and pavement (if required). This design is detailed in plan and profile and duplicated on the final plans. Other construction details, such as fencing, may be combined with the access road detail. See Fences and Gates (Section G 647), Access Roads (Section G 648), and Remodeling (Section G 649).

Other construction, such as aprons for inlets, timber support for C.M.P. outlets, grading, and erosion protection, should also be detailed for duplication on the final plans.

G 364 UTILITIES AND ENCROACHMENTS

The relocation of utilities or removal of encroachments which interfere with a proposed storm drain involves many considerations and procedures necessary for the proper coordination of design. The owners of the facilities to be relocated should be notified as soon as the interference is established. Also, the removal of encroachments on City property or easement should be processed as early as possible to determine any possible complications.

G 364.1 Relocation of Utilities: Having established the facilities (and their ownership) which interfere with the proposed storm drain, the designer must determine who designs, constructs, and pays for their relocation. Generally, the relocations of City storm drains, sewers, traffic signals, and street lights are designed by City design offices and constructed and financed as part of the proposed storm drain project. County storm drains and sewers are also handled as indicated above, except that a permit is required from the owning agency. All utility companies under franchise with the City (such as gas, telephone, telegraph), fire and police signals, and the City Department of Water and Power bear the cost of and relocate their own facilities. If a facility is not under franchise with the City (and this can be established by the Utility and Estimating Division) and there is reason to believe the owner may have prior rights (even if the facility is presently located in a City street), the designer should request a title search on that facility from the Opening and Widening Division. This request should be transmitted with the right of way sketch. Other private facilities (such as oil companies) relocate their own facilities at their own expense unless they have prior rights. Where any prior rights are established, the relocation cost is borne by the City.

To make the utility or other companies aware of the proposed storm drain construction and to coordinate the work, the designer shall notify the companies that their facilities interfere and request their relocation. This may be done through the Utility and Estimating Division or directly to the company by letter. A description of the size and location of the facility and a short summary of the problem involved should be included. Where prior rights are involved, a relocation cost is requested (see Section G 365).

G 364.2 Removal of Encroachments: From a City designer's point of view, an encroachment is the illegal intrusion of private improvement on City property or easement. For example, a property owner's fence may be located, in part or entirely, in a City street. Generally, the intrusion is not intended by the property owner, nor does it become known until it is revealed by a survey. Legally the City can have the encroachment removed by the property owner at his own expense. This is primarily a function of the Street Use Division of the Bureau of Street Maintenance. The designer should limit his activity to determine whether the encroachment interferes with the proposed construction, and if so, whether the removal of the encroachment is in the City's best interest, He must establish whether the improvement was allowed under permit. Necessary removals within an easement to be acquired are part of the easement acquisition.

Before the designer decides to remove an encroachment., he should consider the following factors:

1. Is the removal necessary; can an alternate solution be equally beneficial to the City?

2. Is the removal worthwhile; does it cause undue hardship on the property owner for very little savings to the City?

3. Is the removal practical; can it be done simply?

4. Is the removal wise; will it hurt public relations or create a bad public image?

To get an encroachment removed also involves the consideration of many factors. All building encroachments, carports, bridges, and walls greater than eight feet in height or over 500 square feet in area must be referred to the Bridge and Structural Design Division for the approval of the Municipal Art Department. The partial removal of a tree or its roots should be approved by Street Tree Division of the Bureau of Street Maintenance. If an encroachment is worth salvaging, the designer should request the Street Use Division of the Bureau of Street Maintenance to notify the property owner to see to its removal. The designer must stipulate on the plans whether the encroachment is to be removed by the contractor or is to remain in place.

G 365 REVIEW OF RIGHT OF WAY AND PRIOR RIGHTS

Upon completion of the right of way title search by the Bureau of Right of Way and Land, the Street Opening and Widening Division parcels the right of way map and sends prints to the Design Division or District together with the results of the requested prior rights (if any) on the parcels. The designer shall compare the right of way map with the sketch (Section G 335) to check the alignment. The map is then retained until the designerrequests right of way acquisition.

A prior right is a right established by virtue of being the first party (such as a railroad or utility company) to be granted the use of an easement across privately-owned or city-owned property. Whenever a prior right exists, the designer must include the cost of any relocations (usually substructures) with the project cost.

When prior right exists in an area, the designer should review the horizontal and vertical alignment in search of an economical solution as an alternative to the relocation of the substructure(s) in that area. If this is not successful, the designer should inform the substructure owner (or company) of the proposed relocation and request an estimate of its cost. A plan and profile sketch of the proposed alignment in the area should be enclosed with the request.

When substructures owned by companies under franchise with the City are relocated, the relocation cost is borne by the company (see Subsection G 365.1).

Should additional funds be required, because the original funds were either insufficient in amount or limited as to eligibility, the design office should request such funds by a memo to the Coordinating Division to inform them of the financial problem as soon as possible. If a substantial increase in cost and/or scope of the project is indicated, a revised CAO-39 form and a board report should be submitted with the request as shown in the *Operations and Control Manual*.

The financing of prior right construction may be done by an IDO (Interdepartmental Order, used with other City departments) or an AFE (Authority for Expenditure, used with private ownership), which, when approved by the City Attorney and Board of Public Works, is a short form of agreement to reimburse the owner for the work performed.

G 366 RIGHT OF WAY ACQUISITION

As soon as the extent of the project and the alignment are assured, the designer requests the Opening and Widening Division to acquire the final right of way (Figure G 366). Two copies of the parceled right of way map are corrected to the final requirements and one copy is transmitted with the request. One copy is transmitted to the Projects Control Division. Unless the right of way requirements are revised, this is the last step in right of way procedure by the design office.

In conjunction with the completion of final plans, the designer must also write the preliminary copy of the special provisions (if required).

G 370 FINAL PLANS

The preparation of final plans is delineated in Sections G 710 to G 745. The checking and coordinating, approvals, and transmittals of final plans are given in Sections G 751 to G 753. The procedure of plan processing to completion of construction is shown in Figure G 750.