

Prepared by



for Municipality of Anchorage
Public Works Department

SAND LAKE DRAINAGE AND WATER QUALITY MANAGEMENT DESIGN CRITERIA

PRELIMINARY

TECHNICAL MEMORANDUM

NUMBER TWO

January 21, 1981

SAND LAKE DRAINAGE AND WATER QUALITY
MANAGEMENT STUDY

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DESIGN CRITERIA

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MUNICIPALITY OF ANCHORAGE
DEPARTMENT OF PUBLIC WORKS

BY:

QUADRA ENGINEERING, INC.

JANUARY 21, 1981

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CHAPTER I. DRAINAGE POLICY

1.1 Statement of Policy

The provision of adequate drainage for urban areas is necessary to preserve and promote the general health, welfare, and economic well-being for residents in the Municipality. Drainage is a regional feature that effects all parcels of property. This characteristic of drainage makes it necessary to formulate programs that balance both public and private involvement, although overall coordination and master planning must be provided by the Municipality.

When planning drainage facilities, certain underlying principles provide direction. These principles are made operational through a set of policy statements, and the application of the policy is in turn facilitated by technical criteria and data.

1.2 Principles

Drainage is an element of general urban service development in the Municipality. Therefore, the planning of drainage facilities should be in general conformance with the general development plan of the Municipality which includes land use designations.

Drainage is a space allocation problem. The volume of water present at any given point in time in an urban region cannot be compressed or diminished. It is a space demand which must be considered in the planning process. Because the space required cannot be altered, choice is limited to location considerations. If adequate provision is not made in a land use plan for the drainage demand, storm water runoff will conflict with other land uses and will result in water damage and will impair or even disrupt functioning of other urban systems. Space allocation can provide the key to workable special assessments to finance drainage facilities in other communities. By placing a storage function on all property, persons who seek simply to discharge runoff downstream can only do so at a cost - the prorated costs of conveyance and downstream storage.

Storm water runoff is a resource out of place. Storm water runoff is a part of the urban water resource system and should be considered as such. In urban areas, runoff need not always be looked upon as a liability; it has the potential for beneficial use. When treating storm water runoff as a resource, attention must be given to the quality aspects of the water. This, in turn, relates to street cleaning practices, solid waste collection and removal services, and regulations on the development of raw land to control erosion and resulting silt loads.

An urban drainage strategy should be a multipurpose/multiple means effort. The many competing demands placed upon water within an urban region suggests that a strategy for managing drainage be as multipurpose as practical. Drainage facilities can fulfill a number of purposes. In addition, facilities not designed primarily for drainage frequently can be designed to provide drainage benefits; for example, rooftops that provide detention storage. Another aspect of a drainage strategy is that it must consider multiple means of accomplishing its objectives. In general, there is not one single all-encompassing method of handling storm water.

1.3 Basic Knowledge

The first step in the implementation of a drainage program is to obtain the facts. A program for collecting and analyzing storm runoff and flood data must be undertaken in order that intelligent and orderly planning may be undertaken in the future in regards to storm drainage facilities. The following steps should be taken for basic storm drainage knowledge in the Anchorage area:

- A. Flood damage data should be collected in a systematic and uniform manner.
- B. A comprehensive program to collect and analyze rainfall runoff relationships in urban areas should be initiated and maintained.
- C. An inventory of successful drainage projects in the Anchorage area should be maintained for use as examples.
- D. The Municipality of Anchorage should acquire and actively maintain an urban drainage library available to governmental units and practicing planners and engineers.

1.4 Planning

Storm drainage is a part of the total urban environmental system. Therefore, storm drainage planning and design shall be compatible with the Municipal Comprehensive Plan.

A master plan for storm drainage should be developed and maintained in an up-to-date fashion for all major drainage basins in the Anchorage area. The planning for drainage facilities should be coordinated with the planning for open space, planning for solid waste disposal, and planning for transportation. By coordinating these efforts, new opportunities are identified which can assist in a solution to drainage problems.

Natural drainage ways should be used for storm runoff waterways where possible. Major considerations must be given to the flood plains and open space requirements of the area. Natural drainage ways within an urbanizing area are too often deepened, straightened, aligned, and sometimes put underground. The community loses a natural asset when this happens. In addition, channelizing a natural waterway usually speeds up the flow, causing greater peaks and higher drainage costs downstream, and does nothing to enhance the environment. Drainage ways having slow flow, grassy bottoms and sides, and wide water surfaces provide significant storage capacity. This storage is beneficial in that it reduces downstream runoff peaks and provides the opportunity for groundwater recharge. Wide natural channels provide urban open space as well.

Planning and design of storm water drainage systems should not be based on the premise that problems can be transferred from one location to another. Channel modifications which create unnecessary problems downstream should be avoided, both for the benefit of the public and to obviate damage to private parties. Problems to avoid include erosion and downstream sediment deposition, increase of runoff peaks, and debris transportation.

Storm water runoff can be stored in detention and retention reservoirs. Such storage reduces drainage capacity required, thereby reducing the land area and expenditures required downstream. Acquisition of park land having a relationship to drainage ways can provide area where storm runoff can spread out and be stored for slower delivery downstream. Storage of storm runoff close to points of rainfall occurrences includes use of rooftops, parking lots, ball fields, property line swales, parks, road

embankments, borrow pits, and on-site ponds. Whenever reasonably acceptable from a social standpoint, parks should be used for short-term detention of storm runoff to create drainage benefits. Such use of park land will help justify park and greenbelt acquisition and expenditures.

1.5 Technical Services

Storm drainage planning and designs will adhere to the criteria developed and presented in this design criteria manual. The design criteria manual presents current good engineering practice and shall be utilized in the Anchorage area. The criteria are not intended to be an iron-clad set of rules within which the planner and designer must work; they are intended to establish guidelines, standards, and methods for sound planning and design.

Every urban area has two separate and distinct drainage systems, whether or not they are actually recognized and designed. One is the initial system and the other is the major system. To provide for an orderly urban growth, reduce cost to future generations, and obviate loss of life and major property damage, both systems must be planned and properly engineered. The initial storm drainage system is necessary to reduce street maintenance costs, to provide protection against regularly recurring damage from storm runoff, to help create an orderly urban system, and to provide convenience to the urban residents. Storm drainage systems consisting of underground pipes are part of the initial storm drainage facilities for the initial storm runoff, varying from an expected frequency of recurrence of once in two years to once in ten years, provision shall be made to obviate major property damage and loss of life with the storm runoff expected to occur once each 100 years. Such provisions are known as the major drainage system.

CHAPTER II. SUMMARY OF BASIC DRAINAGE LAW

2.1 General Legal Principles of Drainage Law

A Municipality can be expected to be treated like a private party in drainage matters. Municipal corporations cannot alter the course of drainage or concentrate its flow, nor can they collect surface waters and route it to an adjoining owner any more than an individual can. It is not relevant concerning the question of liability whether the wrongful action is a consequence of purpose or the result of improvements undertaken with no intent to injure the adjoining proprietor. A municipal corporation has no more power over its streets than a private individual has over his own land. The Municipality cannot be permitted to exercise power to the injury of another's property in a manner that would render a private individual responsible for damages without being responsible itself.

The owner of upper land has an easement over lower lands for drainage of surface water flowing in its natural course. This rule is easy to apply between two adjacent private land owners. However, when a government is involved with many lower lands, what is a "natural course" can become more complicated. A Municipality is not liable for gathering surface water within its limits and carrying it along the natural course of drainage and casting it upon private property more quickly than it normally would have reached the same point of discharge. Nor is a Municipality liable because, due to changes made by the Municipality, surface water is discharged into the natural channel at one rather than several points.

Natural drainage conditions may be altered by an upper owner provided the water is not sent down in a manner or quantity more than formerly. The universal rule that one person cannot change the course of drainage and cast upon the land of another water which naturally would not have flowed there applies equally to municipal corporations. The best rule to follow is planning drainage improvements, whether to follow the natural water course or artificially draining surface water, is that a Municipality is liable if it actively injured private property as the result of improvements made to handle surface water. A Municipality is in a much stronger position if it can establish that the improvements followed the natural drainage.

2.2 Drainage Improvements by a Municipal Corporation

A general power to construct and maintain streets is sufficient authority to authorize the construction of

a storm drain to carry out storm water by a municipal corporation. The Municipality of Anchorage has been granted "road powers" or "roads and drainage powers" within certain service areas in accordance with Article IX, Section 9.01, "The Home Rule Charter for the Municipality of Anchorage, Alaska", September 16, 1975. However, the general rule is that a municipal corporation is not liable in damages for wholly failing to prevent damage unless it was made necessary by its own act as would be when through change of street grades, water is cast upon private property. Nor can a municipal corporation be held liable for injuries to property resulting from its failure to undertake the work of clearing and cleaning out a stream running through the Municipality which floods its banks by reason of obstruction in the stream if the Municipality has not adopted the care of the stream. Therefore, where no duty of constructing is imposed, if the Municipality chooses to exercise statutory or charter authority to construct storm drainage, it is not exercising a governmental function, but is voluntarily acting for its own advantage and thus is not exempt from liability to the private actions of persons injured by its negligence in exercising the power so granted and accepted. It is because of this voluntary governmental function being exercised that an almost strict responsibility is placed on a Municipality undertaking drainage improvements to not injure lower land owners.

2.3 Repairs and Maintenance

The operation and maintenance of drains and sewers, the duty to make repairs, and the duty to keep them clear and free of obstruction are a ministerial and not a governmental function, and thus a Municipality is liable for negligent handling of these functions. However, a Municipality has no duty to keep open a private drain. The duty of a government to keep its drainage system in repair involves the exercise of a reasonable degree of watchfulness in ascertaining its condition from time to time and preventing it from becoming delapidated or obstructed. Where this could be guarded against by occasional examination and cleansing, such omission is a neglect of duty. Liability results, whether the drain is a natural water course or artificial construction, so long as the pipe or drain has been adopted by the Municipality for drainage purposes and it has assumed control over it. If catch basins or other appurtenances constructed to carry surface water into the sewers are negligently permitted to become obstructed so that the water flows over on to private property, the Municipality is liable.

2.4 Conclusion

Rivers, streams, creeks, and swales are all part of the natural drainage system. Successful use of the natural drainage system is necessary to render land fit for use of man. As long as natural drainageways are used without exceeding their natural capacity, the owner of land, through which they run, cannot complain that the water is made to flow any faster than it does in a state of nature.

Drainage has both simple and complicated aspects. If the facts are ascertained and a plan developed before initiating a proposed improvement, the likelihood of an injury to a land owner is remote and the Municipality should be able to undertake such improvements relatively assured of no legal complications, and be able to use several different means of financing the improvement.

CHAPTER III. RAINFALL AND RUNOFF

3.1 General

The availability of rainfall data for the Sand Lake area is good. Although no rain gauges are maintained in the Sand Lake area, the closest data collecting station, the U.S. Weather Bureau Station at the International Airport, is located adjacent to the Sand Lake area. However, the lack of adequate and sufficient rainfall maps for the entire Anchorage area severely hampers the planning process for storm drainage systems in other parts of the Municipality.

3.2 Rainfall

A. Storm Recurrence

Storm Recurrence for use in storm drain design shall be as indicated in Table 3.1. Design Hyetographs are given in these tables:

Table 3.2 - Five-Year Recurrence Spring Runoff Event.

Table 3.3 - Five-Year Recurrence Summer Rainstorm Event.

Table 3.4 - Summer Rainstorm event with a five-year recurrence of number of days since 0.10 inch of runoff.

Table 3.5 - Ten-year Recurrence Event.

If for some reason the hyetographs in Tables 3.2 through 3.5 do not suit the engineer's requirements, then a hypothetical storm can be constructed using the curves in Figure 3.1.

B. Water Quality Evaluation Storm

Design hyetographs for use in evaluating water quality impact on receiving waters are given in these tables:

Table 3.6 - Representative spring snowmelt event

Table 3.7 - Summer Rainstorm event with the most frequent volume of runoff

Table 3.8 - Representative summer rainstorm event with the most frequent number of days since 0.10-inch of runoff.

3.3 Runoff Analysis

The analysis of storm runoff, that is, the hydrologic aspects of urban drainage including determination of the peak rate of runoff, the volume, and the time distribution of flow, is that part of the drainage engineer's work which has the greatest effect on the success or failure of his effort. The storm runoff peak, volume, and timing provide the basis for all planning, design, and

Table 3.1

Storm Recurrence
for use in
Storm Drain Design

LAND USE	INITIAL DESIGN STORM RETURN PERIOD (FREQUENCY)
1. Residential	2 Years
2. High Value General Commercial Area	5 Years
3. Public Buildings Area	5 Years
4. Airports	5 Years
5. Major Airport Terminals	10 Years
6. High Value Downtown Business Area	10 Years

Table 3.2
 Design Hyetograph
 March 23, 1974 Storm

<u>Time (Min)</u>	<u>Rainfall Intensity (in/hr)</u>
0.0	0.01
60.0	0.02
120.0	0.02
180.0	0.02
240.0	0.02
300.0	0.02
360.0	0.03
420.0	0.03
480.0	0.03
540.0	0.02
600.0	0.02
660.0	0.01
720.0	0.01
780.0	0.02
840.0	0.01
900.0	0.01
960.0	0.01
1020.0	0.00
1080.0	0.00
1140.0	0.00
1200.0	0.00
1260.0	0.00
1320.0	0.00
1380.0	0.01
1440.0	0.03
1500.0	0.04
1560.0	0.05
1620.0	0.04
1680.0	0.04
1740.0	0.05
1800.0	0.06
1860.0	0.06
1920.0	0.06
1980.0	0.05
2040.0	0.04
2100.0	0.03
2160.0	0.02
2220.0	0.01
2280.0	0.00
2340.0	0.00

Five year recurrence spring runoff event.
 Use for drainage design.

Table 3.3
 Design Hyetograph
 July 21, 1970 Storm

<u>Time (Min)</u>	<u>Rainfall Intensity (in/hr)</u>
0.0	0.06
60.0	0.15
120.0	0.03
180.0	0.08
240.0	0.08
300.0	0.06
360.0	0.04
420.0	0.02
480.0	0.05
540.0	0.01
600.0	0.01
660.0	0.00
710.0	0.00
1080.0	0.00

Summer Rainstorm Event with a five year recurrence of volume of runoff.
 Use for drainage design.

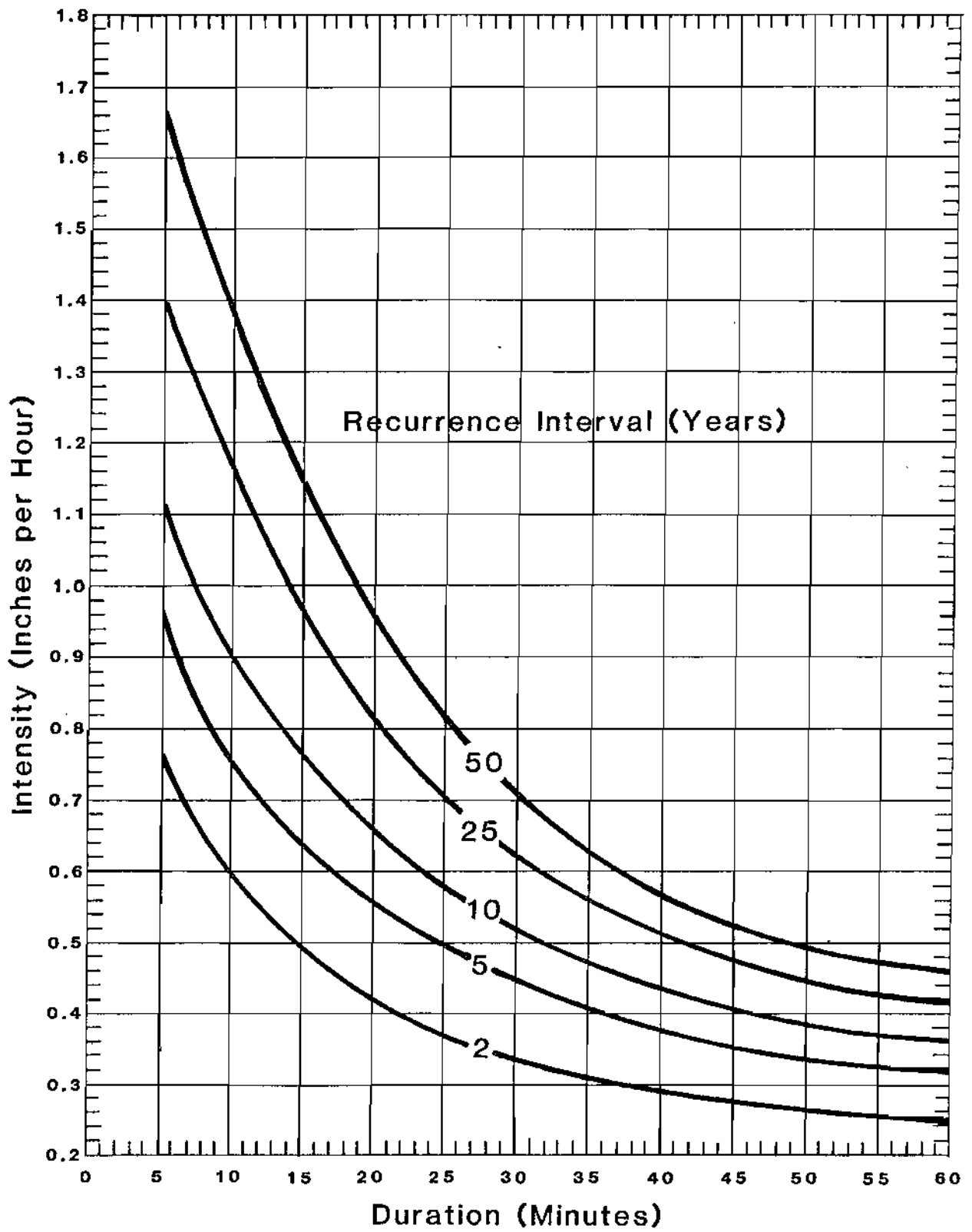
Table 3.4
 Design Hyetograph
 July 24, 1969 Storm

<u>Time (Min)</u>	<u>Rainfall Intensity (in/hr)</u>
0.0	0.02
60.0	0.07
120.0	0.00
180.0	0.00
240.0	0.02
300.0	0.03
360.0	0.02
420.0	0.06
480.0	0.04
540.0	0.10
600.0	0.10
660.0	0.04
720.0	0.06
780.0	0.05
840.0	0.05
900.0	0.13
960.0	0.17
1020.0	0.16
1080.0	0.15
1140.0	0.10
1200.0	0.07
1260.0	0.02
1320.0	0.01
1380.0	0.03
1440.0	0.04
1500.0	0.00
1560.0	0.00
1620.0	0.00
1680.0	0.00

Summer Rainstorm event with a five year recurrence of number of days since 0.10-inch of runoff.
 Use for drainage design.

Table 3.5
Ten Year Recurrence Event
August 26, 1953 Storm

<u>Time (Min)</u>	<u>Rainfall Intensity (in/hr)</u>
0	0.0
15	0.65
30	0.55
45	0.10
60	0.0



RAINFALL INTENSITY/DURATION/FREQUENCY CURVES
Anchorage, Alaska

Figure 3.1

Table 3.6
Design Hyetograph
March 10, 1969 Storm

<u>Time (Min)</u>	<u>Rainfall Intensity (in/hr)</u>
0.0	0.02
60.0	0.02
120.0	0.02
180.0	0.02
240.0	0.02
300.0	0.02
360.0	0.03
420.0	0.03
480.0	0.03
540.0	0.02
600.0	0.02
660.0	0.02
720.0	0.01
780.0	0.00
1380.0	0.00
1440.0	0.01
1500.0	0.01
1560.0	0.01
1620.0	0.00

Representative spring snowmelt event.
Use to evaluate water quality impact.

Table 3.7
 Design Hyetograph
 September 4, 1968 Storm

<u>Time (Min)</u>	<u>Rainfall Intensity (in/hr)</u>
0.0	0.02
60.0	0.02
120.0	0.03
180.0	0.07
240.0	0.04
300.0	0.02
360.0	0.06
420.0	0.04
480.0	0.02
540.0	0.02
600.0	0.03
660.0	0.01
720.0	0.00
780.0	0.00
840.0	0.01
900.0	0.03
960.0	0.02
1020.0	0.00
1080.0	0.00
1140.0	0.00
1200.0	0.00
1260.0	0.00

Summer Rainstorm event with the most frequent volume of runoff.
 Use to evaluate water quality impact.

Table 3.8
Design Hyetograph
August 8, 1974 Storm

<u>Time (Min)</u>	<u>Rainfall Intensity (in/hr)</u>
0.0	0.01
60.0	0.00
120.0	0.00
180.0	0.01
240.0	0.00
300.0	0.02
360.0	0.02
420.0	0.01
480.0	0.00
540.0	0.00
600.0	0.00
660.0	0.00
720.0	0.00
780.0	0.00
840.0	0.01
900.0	0.02
960.0	0.00
1020.0	0.00
1080.0	0.00
1140.0	0.00
1200.0	0.00
1260.0	0.01
1320.0	0.09
1380.0	0.16
1440.0	0.00
1500.0	0.02
1560.0	0.01
1620.0	0.01
1680.0	0.00
1740.0	0.00
1800.0	0.03
1860.0	0.03
1920.0	0.01
1980.0	0.00
2040.0	0.00
2100.0	0.00
2160.0	0.03
2220.0	0.03
2280.0	0.01
2340.0	0.00
2520.0	0.00

Representative summer rainstorm even with the most frequent number of days since 0.10-inch of runoff.
Use to evaluate water quality impact.

construction of drainage facilities. To be in error on the hydrology means that the works are either undersized, oversized, or out of hydraulic balance. On the other hand, it must be kept in mind that the result of the runoff analysis is an approximation.

Three basic approaches in the analysis of storm runoff should be utilized in the Municipality of Anchorage for determining the character of urban storm runoff. They are the rational method, the ILLUDAS computer model, and the SAM computer model. The Rational Method is recommended for storm drain design and overland flow from tributary basins generally less than ten acres in area. For larger areas from 10 to 40 acres in size and where water quality is not a significant aspect, the ILLUDAS computer model should be used. It is felt that this size area justifies significantly more study, thought, and judgment on the part of the engineer than is permitted by the rational method. SAM computer model is recommended for areas larger than 40 acres and areas which may have water quality problems. The level of sophistication provided by the SAM computer model does not justify its use on areas smaller than 40 acres in size unless a water quality analysis is required.

A. Rational Method

For basins that are not complex and generally ten acres or less, it is recommended that the design storm runoff be analyzed by the rational method. This method was first introduced in 1889 and is used in most engineering offices in the United States. Even though this method has frequently come under academic criticism for its simplicity, no other practical drainage design method has been evolved to a level of general acceptance by the practicing engineer.

The rational method is based upon the rational formula:

$$Q=CIA$$

Q is defined as the maximum rate of runoff in cubic feet per second.

C is a runoff coefficient which is the ratio between the maximum rate of runoff from the area and the average rate of rainfall intensity, in inches per hour, for the period of maximum rainfall of a given frequency of occurrence having a duration equal to the time of concentration.

I is the average intensity of rainfall in inches per hour for duration equal to the time of

concentration. The time of concentration is usually the time required for water to flow from the most remote point of the area to the point being investigated.

The basic assumptions made when the rational method is used are:

1. The computed maximum rate of runoff to the design point is a function of the average rainfall rate during the time of concentration to that point.
2. The maximum rate of rainfall occurs during the time of concentration, and the design rainfall depth during the time of concentration is converted to the average rainfall intensity for the time of concentration.
3. The maximum runoff rate occurs when the entire area is contributing flow.

The rational method is a wholly adequate method of approximating the peak rate of runoff from a rainstorm in a given basin. The greatest drawback to the rational method is that it normally provides only one point on the runoff hydrograph. When the basins become complex and where sub-basins come together, the rational method will overestimate the actual flow and will result in oversizing drainage facilities. One reason the rational method is limited to small areas is that good design practice requires the routing of hydrographs from larger basins for economic design. Another disadvantage of the rational method is that with typical design procedures, one normally assumes that all of the design flow is collected at the design point and that there is no "carryover water" running overland to the next design point. However, this is not the fault of the rational method, but of the design procedure.

The runoff coefficient, C , is the variable of the rational method least susceptible to precise determination and requires judgement and understanding on the part of the engineer. Its use in the formula implies a fixed ratio for any given drainage area. In reality, this is not the case. The coefficient represents the intergraded effects of infiltration, detention storage, evaporation, retention, flow routing, and interception, which all affect the time distribution and peak rate of runoff. Table 3.9 presents some recommended values for C . The coefficients in these two tables are applicable for storms of the five to ten year frequency. Less

Table 3.9
Rational Method Runoff Coefficients

<u>Description of Area</u>	<u>Coefficient of Runoff</u>
<u>Business:</u>	
Downtown Areas	0.70 to 0.95
Neighborhood Areas	0.50 to 0.70
<u>Residential:</u>	
Single Family Areas	0.30 to 0.50
Multi. Units	0.40 to 0.75
Residential, Suburban	0.25 to 0.40
Apartment Dwelling Areas	0.50 to 0.70
<u>Industrial:</u>	
Light Areas	0.50 to 0.80
Heavy Areas	0.60 to 0.90
Parks, Cemeteries	0.10 to 0.25
Playgrounds	0.20 to 0.35
Railroad Yard Areas	0.20 to 0.40
Unimproved Areas	0.10 to 0.30

frequent, higher intensity storms require modifications of the coefficient because infiltration and other losses have a proportionately smaller effect on the runoff.

Adjustments of the rational method for use with major storms can be made by multiplying the right side of the rational formula by a frequency factor $C(f)$, which is used to account for the antecedent precipitation conditions. The rational formula now becomes: $Q=CIA C(f)$. Table 3.10 provides a table of $C(f)$ values which can be used. The product of $C \times C(f)$ should not exceed 1.0.

B. The Illinois Urban Drainage Area Simulator (ILLUDAS) Computer Model

ILLUDAS is a digital computer model that uses storm rainfall and physical basin parameters to predict storm runoff from both paved areas and grassed areas. ILLUDAS utilizes the directly connected paved area concept of the British Road Research Laboratory method, but also recognizes and reproduces runoff from grassed and non-connected paved areas. ILLUDAS is available as a Fortran IV program in the Anchorage area by the Municipality of Anchorage through Boeing Computer Services.

The principle elements in the computation of runoff from directly connected paved areas are as follows. Equal time increments of rainfall are applied to the directly connected paved area in a small sub-basin of the total urban basin. Next, a computation is made of the travel time required for each increment of runoff to reach the inlets at the downstream end of the sub-basin. In this way, a surface hydrograph is provided for each sub-basin. These surface hydrographs from each sub-basin are accumulated in a downstream order through the basin. This cumulation of inflow hydrographs is routed through each section of pipe to account for the temporary storage within each pipe section. The result is a computed outflow hydrograph from each section of pipe, and ultimately a hydrograph at the outlet of the total basin.

ILLUDAS is applied by first dividing the basin to be studied into sub-basins. A sub-basin is normally a homogeneous portion of the basin tributary to a single inlet or set of inlets that constitutes a design point in the drainage network. Two physical factors must be evaluated for each sub-basin. First, a paved area directly connected to the storm drainage system must be determined; second, the travel time from the farthest point from the paved area to the design point must be calculated.

Table 3.10

FREQUENCY FACTORS FOR RATIONAL FORMULA

<u>Recurrence Interval (years)</u>	<u>C_f</u>
2 to 10	1.0
25	1.1
50	1.2
100	1.25

The various elements and steps used in developing a runoff hydrograph from the contributing paved area of an urban sub-basin are given in the publication, "The Illinois Urban Drainage Area Simulator, ILLUDAS", Bulletin 58, by Michael L. Terstriep and John B. Stall, published by the State of Illinois, Illinois State Water Survey, Urbana. A copy of this bulletin is available at the Municipal Public Works Department.

C. System Analysis Model (SAM)

SAM represents a compromise between the simplest and the most comprehensive attempts that have been made in the modeling waste water collection systems. The purpose of SAM is to predict time-dependent parameters such as flow rate, hydraulic grade line, and concentrations with acceptable accuracy for detailing planning purposes at a moderate cost. The model has been developed in independent modules; this module structure makes the addition of additional independent models feasible. The program is written using Fortran IV programming conventions.

The computer model has six separate sections: the runoff model, the dry weather flow model, the subsurface model, the infiltration/inflow model, the water quality model, and the transport model.

The SAM model is a more advanced model than ILLUDAS in several different aspects. SAM uses a more sophisticated method for the transport of storm water. SAM also allows the user to examine water quality impacts on receiving waters. In addition, SAM has contingencies for sanitary and storm water combinations and dry weather flow modeling.

The SAM computer model is currently available in the Anchorage area through Boeing Computer Services Computer in conjunction with the Municipality of Anchorage. A user's manual for SAM can be obtained from the Municipality of Anchorage Public Works Department.

CHAPTER IV. STORM DRAINAGE CRITERIA FOR STREETS

4.1 General

Streets serve an important and necessary drainage service, even though their primary function is for the movement of traffic. Traffic and drainage uses are compatible up to a point, beyond which drainage is, and must be, subservient to traffic needs.

Gutter flow in streets is necessary to transport runoff water to storm inlets and to major drainage channels. Good planning of streets can substantially help in reducing the size of, and sometimes eliminating the need for, a storm drain system in newly-urbanized areas.

Good drainage design provides direct traffic benefits and lowers street maintenance costs. Proper drainage design should have as one of the prime objectives the protection of street paving and its subgrade from unnecessary deterioration.

4.2 Classification of Streets

Drainage practices as related to streets are dependent upon the type of street used and construction. The following represents the classification of streets based upon traffic volume, parking practices, design and construction relationships to cross streets and other criteria as presented so that storm drainage practices may be related to the street use.

Residential

A residential street is a minor traffic carrier within a neighborhood which is usually characterized by two moving lanes and parking along the curb. A residential street has a minimum right-of-way width of 50 to 60-feet with slope easements, and back to back of curb width of 26, 33, or 36-feet. Twenty-six foot street sections are restricted to streets within PUDs where on-street parking is prohibited. The 33-foot section is restricted to streets with a maximum average daily traffic count of 400 vehicles.

Collector

The function of a collector street is to collect and distribute traffic between arterial and residential streets. The Municipality further differentiates collector streets by Type 1 and Type 2. A Type 1 collector is a residential collector with a minimum right-of-way width of 60-feet and a back to back curb width of 45-feet. Sidewalks may be required where heavy pedestrian traffic may be encountered. Type 2

collectors have a minimum right-of-way width of 70-feet and a back to back curb width of 49-feet. Type 2 collectors are generally associated with higher traffic volumes than Type 1.

Arterial

An arterial street permits rapid and relative unimpeded traffic movement throughout the city. With the exception of the downtown area, arterials require a right-of-way width of between 80 to 100-feet and accommodate between two and six lanes of traffic. Depending upon the number of lanes, the arterial can carry up to 30,000 vehicle trips per day.

Freeways and Expressways

A freeway or expressway permits rapid and unimpeded movement of traffic through and around the Municipality. Access to the freeway or expressway is usually controlled by interchanges at major arterial streets. Freeways and expressways normally carry over 30,000 vehicle trips per day, and accommodate up to eight lanes of traffic.

Country Lanes and Mountain Roads

Country lanes and mountain roads are designations for local and collector streets in low or sparsely populated urban areas. Standards vary with the terrain, vegetation, and surrounding land uses. Roads may be gravel or paved and are generally narrow.

Alleys

Alleys are streets with inverted crowns with a right-of-way width of 20-feet and a surface width of 18-feet in residential areas or 20-feet in commercial areas. This type of street is used for alternative and off-street access.

4.3 Effect of Storm Water Runoff on Street Traffic Capacity

Storm runoff which influences the traffic carrying capacity of a street can be classified as follows:

- A. Sheet flow across the pavement as falling rain flows to the edge of the pavement.
- B. Runoff flowing adjacent to the curb.
- C. Storm water ponded at low points.
- D. Flow across the traffic lane from an external source, cross-street flow as distinguished from water falling on the pavement surface.

E. Splashing of any of the above types of flow on pedestrians.

Each of these types of storm water runoff must be controlled within acceptable limits so that the street's main function as a traffic carrier will not be unduly restricted.

Rainfall which falls upon the paved surface of the street or road must flow overland in what is referred to as sheet flow until it reaches a channel. In streets which have curbs and gutters, the curb and gutter become the channel, while on roads which have drains and ditches adjacent to them, the ditches become the channel. Traffic interference due to sheet flow is essentially two types, hydroplaning and splash.

Water which enters a street, either by sheet flow from the pavement surface or overland flow from adjacent land area, will flow in the gutter of the street until it reaches some outlet such as a storm drain or channel. Interference due to gutter flow predominantly affects streets where parking is not permitted, as with many arterial streets, because whenever the flow width exceeds a few feet it will significantly affect traffic. Field observations show that vehicles will crowd adjacent lanes to avoid curb flow. This creates a traffic hazard which contributes to the rash of small accidents which generally occur during rainstorms.

Storm runoff ponded on the street surface because of grade changes or the ground slope of intersecting streets has a substantial effect on the street carrying capacity. A major problem with ponding is that it may reach depths greater than the curb and remain on the street for long periods of time. Another problem is that ponding is localized in nature and vehicles may enter a pond moving at a high rate of speed.

Whenever storm runoff other than sheet flow moves across a traffic lane, a serious impediment to traffic flow occurs. The cross-flow may be caused by superelevation of a curve, a street intersection, exceeding the capacity of the higher gutter on a street with cross-fault, or simply, a poorly designed street. The problem associated with this type of flow is the same as for ponding in that it is localized in nature and vehicles may be traveling at a high speed when they reach the location. If the velocity of the vehicle is naturally slow and its use is light, such as on residential streets, cross-flow does not cause sufficient interference to be objectionable. The depth and velocity of cross-flow should always be maintained within limits that it will not have sufficient force to affect moving traffic.

4.4 Storm Drainage Criteria for Urban Streets

The following section presents specific design requirements for storm drainage on urban type streets. The methods employed to meet these requirements are the designer's option, so long as they are in compliance with the criteria in other parts of this manual and with the Municipality of Anchorage Standard Specifications.

A. Street Capacity for Initial Storms

Determination of street carrying capacity for the initial storm shall be based upon two considerations:

1. Pavement encroachment for computed theoretical flow conditions.
2. An empirical reduction of the theoretical allowable rate of flow to account for practical field conditions.

The pavement encroachment for the initial storm shall be limited as set forth in Table 4.1. The storm drain systems should commence at the point where the maximum encroachment is reached and should be designed on the basis of the initial storm. Development of the major drain system is encouraged so that the initial runoff is removed from streets, thus making the point at which the storm drain system must begin further downstream.

When the allowable pavement encroachment has been determined the theoretical gutter carrying capacity for a particular encroachment shall be computed using the modified Manning formula:

for flow in shallow traingular channel. An n value of 0.016 shall be utilized unless special considerations exist.

B. Ponding

The term "ponding" shall refer to areas where runoff is restricted to the street service by sump inlets, street intersections, low points, intersections with drainage channels, or other reasons. Limitations for pavement encroachment by ponding for the initial storm shall be those presented in Table 4.1, Allowable Use of Streets for Initial Storm Runoff. These limitations shall determine the depth

Table 4.1

Allowable Use of Streets for Initial Storm Runoff In Terms of Pavement Encroachment

<u>Street Classification</u>	<u>Maximum Encroachments</u>
Residential	No curb over topping* Flow may spread to crown of street
Collector	No curb over topping* Flow spread must leave at least one lane free of water.
Arterial	No curb over topping* Flow spread must leave at least one lane free of water in each direction.
Freeway and Expressway	No encroachment is allowed on any traffic lane.
Paved Alleys	Flow spread shall not extend over property lines

*Where no curbing exists, encroachment shall not extend over property lines.

allowable at inlets, gutter turnouts, culvert head waters, etc.

C. Cross-Street Flow

Cross-street flow is in two general categories. The first type is runoff which has been flowing in a gutter and flows across a street to the opposite gutter or inlet. The second type is flow from an external source such as a drainage way which will flow across the crown of the street when the conduit capacity beneath the street is exceeded. Cross-street flow depth shall be limited as set forth in Table 4.2.

Where cross-street flow is caused by exceeding the capacity of the drainage structure crossing beneath the street, measures shall be taken to insure that the street will not be unnecessarily damaged by the cross-street flow. This may require protective headwalls, riprap, or other measures.

4.5 Storm Drainage Criteria for Rural Streets

Rural streets are characterized by the use of roadside drainage ditches for drainage purposes, as opposed to curbs and gutters. The majority of requirements put forth for typical urban streets are applicable for rural streets. Certain special considerations necessary for proper design of rural streets are set forth in this section.

The termination of street carrying capacity for the initial storm shall be based upon the following considerations:

1. Pavement encroachment is allowed.
2. Maximum allowable velocity to prevent scouring.

The same limitations as expressed in Table 4.1, Allowable Use of Streets for Initial Storm Runoff, shall govern rural streets.

Once the pavement encroachment has been established, the maximum allowable velocity for the drainage channel shall be determined from Table 4.3, Permissible Velocities for Roadside Drainage Ditches. Design velocities for all lining should not fall below 2-feet per second for the initial runoff to minimize sedimentation problems. The allowable capacity for

Table 4.2
Allowable Cross Street Flow

<u>Street Classification</u>	<u>Initial Design Runoff</u>	<u>Major Design Runoff</u>
Residential	6-inch depth at crown or in cross pan	18 inches of depth above gutter flowline
Collector	Where cross pans allowed, depth of flow shall not exceed 6 inches.	18 inches of depth above gutter flowline
Arterial	None	6 inches or less over crown
Freeway and Expressway	None	6 inches or less over crown

TABLE 4.3

PERMISSIBLE VELOCITIES FOR ROADSIDE DRAINAGE DITCHES

Channels with Erodible Linings

Soil Type or Lining (earth, no vegetation)	Permissible Velocity (fps)
Fine Sand (noncolloidal)	2.5
Sandy Loam (noncolloidal)	2.5
Silt Loam (noncolloidal)	3.0
Ordinary Firm Loam	3.5
Fine Gravel	5.0
Stiff Clay (very colloidal)	5.0
Graded, Loam to Cobbles (noncolloidal)	5.0
Graded, Silt to Cobbles (noncolloidal)	5.5
Alluvial Silts (noncolloidal)	3.5
Alluvial Silts (colloidal)	5.0
Coarse Gravel (noncolloidal)	6.0
Cobbles and Shingles	5.5
Shales and Hard Pans	6.0

Roadside Channels Lined with Uniform Stand of Various Grass Covers
and Well Maintained

Cover	Slope Range (Percent)	Permissible Velocity (fps)	
		Erosion Resistant Soils	Easily Eroded Soils
Bermuda Grass	0-5	6.0	5.0
Crested Wheat Grass			
Buffalo Grass			
Kentucky Bluegrass			
Smooth Brome			
Blue Grama	5-10	5.0	4.0
Grass Mixture	over 10	4.0	3.0
	0-5	4.0	3.0
Lespedeza Sericea Weeping Lovegrass Yellow Bluestem Kudzu Alfalfa Crabgrass Common Lespedeza Sudangrass	5-10	3.0	2.5
	0-5	3.0	2.0

Design velocities for all linings should not fall below 2 fps for the initial runoff to minimize sediment depositional problems. The allowable capacity for the drainage ditch should be calculated using Mannings formula with an appropriate n value. If the natural channel slope would cause excessive velocity, drop structures, checks, riprap, or other suitable channel protection shall be employed. Design depths shall be limited to 1.5 feet, and preferably less than 1.0 foot.