Minnesota Pollution Control Agency

Water Quality

Wastewater Review and Guidance

Design Flow and Loading Determination Guidelines for Wastewater Treatment Plants

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Contents:

The determination of design flows and pollutant loadings is one of the most important items in the planning of a new or expanded wastewater treatment facility. A detailed analysis of existing flow conditions and the use of adequate flow estimates will determine the hydraulic and pollutant removal capacity needed to properly treat the wastewater and comply with permit conditions. It is necessary to include all contributing flow streams and pollutant loading sources in this analysis, including all residential, seasonal, institutional, commercial, industrial, inflow, infiltration, return and recycle streams and any other unique aspect of flow and pollutant contributions.

These guidelines are the recommended procedures for estimating the design flow and pollutant loading conditions, and are considered to be the minimum values necessary to assure adequate treatment facility capacity. It is expected that sound engineering judgment will be used to determine the appropriate design conditions for each individual treatment facility and that consideration will be given to impacts of decisions on upstream and downstream unit processes.

Introduction

The flow monitoring period for any particular project must record flow data during critical low as well as peak wet weather flow events. Data collected during these flow periods are used to estimate the four flow conditions that are critical to the design and operation of wastewater treatment plants including average dry weather (ADW), average wet weather (AWW), peak hourly wet weather (PHWW), and peak instantaneous wet weather (PIWW).

The <u>average dry weather</u> flow is the daily average flow when the ground water is at or near normal and a runoff condition is not occurring.

<u>Average wet weather</u> or peak month flow is the daily average flow for the wettest 30 consecutive days for mechanical plants or for the wettest 180 consecutive days for controlled discharge pond systems. The 180 consecutive days for pond systems should be based on either the storage period from approximately November 15 through May 15 or the storage period from approximately May 15 through November 15.

The <u>peak hourly wet weather</u> flow is the peak flow during the peak hour of the day at a time when the ground water is high and a five-year one-hour storm event is occurring. To determine this five-year one-hour storm event for the specific project, please refer to the attached Map Number 1.

The <u>peak instantaneous wet weather</u> flow is the peak instantaneous flow during the day at a time when the ground water is high and a twenty-five year one-hour storm event is occurring. To determine the appropriate twenty-five year one-hour storm event, please refer to Map Number 2.

Where the Minnesota Pollution Control Agency (MPCA) determines that the above design flow considerations will not provide adequate protection to the receiving waters, facility capacity in excess of peak instantaneous wet weather flow may be required.

In cases where flow studies are over five years old, or where the consultant designing the treatment or transmission facility did not perform the flow study, a verification of the acceptability of the flow data should be performed.

Table 1 contains a summary of the minimum recommended flow and loading conditions for only a select group of processes. Specific design parameter details for individual treatment process units shall be in accordance with Ten States Standards.

Table 1: Design Conditions Summary

Item	Design
Collection System	Must be capable of transporting all flow to the treatment facility without bypassing.
Lift Station	Must be capable of transporting all flow to the treatment facility without bypassing.
Sanitary Sewers	100 gpcd (Other flows may be approved provided adequate justification is provided. In no case will a flow of less than 75 gpcd be approved.) + 80 gpcd for seasonal visitors + 20 gpcd for out-of-town student + commercial, industrial, and other non-residential flow
Organic Loading	Minimum BOD of 0.17 #pcd plus commercial, industrial, and other non-residential flow
Organic Loading	Minimum TSS of 0.20 #pcd plus commercial, industrial, and other non-residential flow
Peak Hourly Wet Weather with new collection systems	Actual flow data; or Ten States Standards Figure 1, Chapter 10; or 2.5 times AWW for residential, commercial + peak hourly industrial flow
Peak Instantaneous Wet Weather with new collection systems	Actual flow data; or 2.5 times AWW for residential, commercial +peak hourly industrial flow
Flow Equalization Basin	If PHWW/ADW $\geq$ 3, flow equalization must be considered. If PHWW/AWW $\geq$ 3, flow equalization must be considered. If equalization is not provided, a discussion of how the facility will handle the transition in flow must be included. See page 4
Facility Piping and Pumping	PIWW
Preliminary Treatment Unit (screens, grit removal, influent filters, etc.)	PIWW
Clarifiers (surface settling rate and weir loading rate)	PHWW + recirculation flow see “Ten States Standards”
Disinfection (detention time)	PHWW see (Ten States Standards)

Design Flows

Design flow determinations shall be made from actual facility flow data to the extent possible. The probable degree of accuracy of the data shall also be evaluated. This reliability estimation should include an evaluation of the accuracy of the existing data measurement, as well as the reliability of estimates of flow reductions or contributions from infiltration and inflow. Critical data and methodology used should be discuss in the facility plan or other engineering documents. A discussion of a method to use when existing flow data is available and when it isn't available is discuss below.

Treatment Systems with New Sanitary Sewer Collection Systems

For mechanical plants, if the industrial flow varies during the day or week, the design flow should be based on the average flow on the peak day during the period when the industry or industries are operating. This condition is called "rated flow." For example, if the industry discharges 10,000 gallons over eight of the twenty-four hours, the rated flow is 30,000 gallons per day. For controlled discharge pond systems, if the industrial flow varies during the day or week, the average design flow may be based on a weekly average.

The peak hourly wet weather design flow are the sum of the average wet weather design flow for residential (full-time and seasonal), commercial and out-of-town students multiplied by a peaking factor, plus the peak hourly industrial flow. The peaking factor shall be determined in accordance with Figure 1, in Chapter 10 of Ten States Standards.

The MPCA may approve of an alternative flow design with appropriate justification. For determining the design of the collection system (including design flow), refer to Chapter 20 Design of Sewers from "Recommended Standards for Sewage Works" (Ten States Standards).

Some form of permit "control language" may be included for wastewater treatment facilities if the per capita design flow is less than what is recommended in this document. For this situation, it may be a permit violation with "no more connections" when the permitted design flow is reached. Violation of the permitted flow could result in the requirement for submittal of a report that examines the flow in comparison to the number of connections and the number of people using the system. The permittee could also be required to plan, design, and build additional treatment units upon reaching the design capacity.

Treatment Systems with Existing Sanitary Sewer Systems

For a mechanical plant, if a separate sanitary sewer system exists, the attached Table 2 should be used to determine the peak hourly wet weather flow, the peak instantaneous wet weather flow, the average dry weather flow, and the average wet weather flow.

Part A of Table 2 and Figure 1 are used to determine the peak hourly wet weather flow. The measured flow should be plotted for a twenty-four hour period when ground water is at or near normal and a runoff condition is not occurring (Curve X on Figure 1). The ground water elevation in relation to the sewer elevation should be noted. The present peak hourly dry weather flow [(1) on Figure 1 and Table 2] is peak hourly flow during the twenty-four hour period when the ground water is at or near normal and a runoff condition is not occurring. The measured flow should be plotted for a twenty-four hour period when ground water is high and a runoff condition is not occurring (Curve Y). The ground water elevation in relation to the sewer elevation should be noted. Number (2) on Figure 1 and Table 2 is the peak hourly flow during a high groundwater period for that specific area and system when a runoff condition is not occurring. This flow (2) minus the present peak hourly dry weather flow (1) is the peak hourly infiltration.

The measured flow should be plotted for a twenty-four hour period when the ground water is high and a runoff condition is not occurring (Curve Z). This should include overflow, bypasses, and emergency pumping. The amount of rainfall and its duration should be plotted on the same graph. The peak inflow is represented by the greatest distance between Curve Y and Curve Z. The present hourly flow at the point of greatest distance between Curve Y and Z [(5) on Figure 1 and Table 2] minus the present hourly flow during high ground water at the same time of day [(6) on Figure 1 and Table 2] is the peak hourly inflow. It may be necessary to adjust the measured flow based on a relationship between the data attained during a major storm event and the five-year one-hour designed storm event. Items (10) and (13) are determined through a cost effectiveness evaluation. The gpcd contribution for population increase in item (15) [also in (25), (33), and (41)] should be 100 gpcd.

Part B of the table determines the peak instantaneous wet weather flow. The present peak hourly inflow adjusted for a five-year one-hour rainfall event [see part A(8)] is subtracted from the peak hourly wet weather flow [see part

A(19)]. To this number, add the present peak hourly inflow adjusted for a twenty-five year one-hour storm event. The resulting number is the peak instantaneous wet weather flow.

Part C of Table 2 determines the average dry weather flow. The present average dry weather flow (24) is the average flow received over a twenty-four hour period when the ground water is at or near normal and a runoff condition is not occurring. If the industrial flow varies during the day or week, the present average dry weather flow should be based on the average flow of the peak day during the period when the industry or industries are operating (rated flow). This also applies to the average flow from industrial increases.

Part D of the table determines the thirty-day average wet weather design flow. The average infiltration and inflow after rehabilitation (where rehabilitation is cost effective) is the wettest thirty-day average. The amount of infiltration after rehabilitation averaged over the thirty wettest days should be the same or nearly the same as the peak infiltration after rehabilitation. This is due to the fact that the ground water could stay high for a fairly extended period of time. The amount of inflow after rehabilitation averaged over the thirty wettest days depends on the type of sources, their location, the amount of rainfall that affects the source, etc.

Part E of Table 2 correlates all related information that can impact the degree of accuracy of the determination of design flows. It is recommended that a minimum of six months of accurate data be recorded. Minnesota Rules 7077.0150 subp. 2(b) requires a minimum of 30 consecutive days of actual flow monitoring. Data associated with the critical peak wet weather flow events for a sustained wet weather period are essential for accurate estimation of design flows. Critical peak wet weather flow events typically occur in the spring (March-June) and must include the condition of high ground water with inflow.

Controlled Discharge Pond Systems with Existing Sanitary Sewer Systems

The peak hourly wet weather and the peak instantaneous wet weather design flows to a pond system with an existing sanitary sewer system are arrived at in the same manner as in Parts A and B of the previous section. If the present industrial flow varies during the day or week, the present average dry weather flow (24) and (30) may be based on a weekly average. When computing the average wet weather flow, the average infiltration after rehabilitation (31), and the average inflow after rehabilitation (32) are averages over the wettest 180 consecutive days.

Flow Equalization

This section applies to all treatment facilities except pond systems. During a period of high ground water for that area and system, if the ratio of peak hourly wet weather design flow to average wet weather design flow [which is (19) divided by (37)] is three or more, flow equalization shall be evaluated. When the ratio is three or more and flow equalization is not employed, an explanation must be included outlining how the plant will handle this transition from average wet weather design flow to peak hourly wet weather design flow.

During a normal ground water period, if the ratio of the peak hourly design flow during the five-year one-hour storm event [(1)+(14)+(15)+(17)+(18)] to the average dry weather design flow (29) is three or more, flow equalization shall be evaluated. When the ratio is three or more and flow equalization is not employed, an explanation must be included outlining how the plant will handle this flow transition.

Infiltration and Inflow (I/I)

Inflow means water other than wastewater that enters a sewer system from sources such as roof leaders, foundation drains, yard drains, manhole covers, cross connections between storm sewers and sanitary sewers, catch basins, storm water runoff and other drainage structures.

Infiltration means water other than wastewater that enters the sewer system from the ground through defective pipe, pipe joints, and manholes.

I/I is a part of every collection system and must be taken into account in the determination of an appropriate design flow.

Excessive infiltration means the quantity of flow that is more than 120 gpcd (domestic base flow and infiltration).

Excessive inflow means the quantity of flow during storm events that results in chronic operational problems related to hydraulic overloading of the treatment system or that results in a total flow of more than 275 gpcd (domestic and industrial base flow plus infiltration and inflow). Chronic

operational problems may include surcharging, backups, bypasses, and overflows.

If excessive levels of infiltration or inflow exist in the system, a comparison of alternatives for elimination of the excessive flow and treating the excessive flow shall be included with the design summary.

Bypass/Overflow

All bypass/overflow structures shall be manually controlled and kept locked at all times. All bypassing is regulated by permit and is prohibited. An upset defense may be available if: 1) bypass was unavoidable to prevent loss of life, personal injury or severe property damage; 2) there was no feasible alternative to the bypass; or 3) the permittee gives previous notice of an anticipated bypass.

Any bypassing must be reported to the MPCA in a report consistent with permit requirements. This report shall include, but not be limited to, the bypass duration, estimated volume and associated meteorological conditions. Refer to the facility permit for specific bypass requirements. All bypasses and overflows must be immediately reported to the MN Duty Officer at 1-800-422-0798 (outstate) or (651) 649-5451 (Twin Cities Metro Area).

The MPCA may require a corrective action plan to mitigate frequent and/or unjustified bypass events. Failure to follow the proper bypass notification procedures or resolve problems in a timely manner may subject the permittee to enforcement actions, including monetary penalties.

The following design flow considerations may be required to be incorporated into new or existing treatment facilities on a temporary or full time basis in order to reduce the frequency as well as degree of adverse environmental impact associated with bypassing:

A. The treatment facility shall provide pretreatment for the removal of coarse floatable and/or settleable solids during flows in excess of peak instantaneous wet weather. In addition, the pretreated wastes shall then be blended with the fully treated effluent, where practical, and discharge samples collected for the purpose of determining NPDES/SDS permit compliance of the blended effluent.

B. Flow equalization for mechanical plants may be necessary in order to effectively operate treatment plants. Please refer to the section entitled Flow Equalization.

Essential Project Components Percentage

Minnesota Rules 7077.0111 to 7077.0292 apply to the MPCA's administration of financial assistance programs for the construction of municipal wastewater treatment systems. The assistance programs include the Wastewater Infrastructure Fund (WIF) and the State Revolving Fund (SRF) loan program. These rules require the calculation of an "essential project components percentage." The percentage will be used by the Public Facilities Authority (PFA) in their determination of a project's cost that may qualify for assistance with the WIF. Please see Table 3 for more information on calculating an essential project components percentage.

Wastewater Treatment Plant Design Loading

Table 4 should be used to determine the design loadings for the upgraded wastewater treatment plant.

For More Information

Please contact the engineer assigned to the project or District. If the engineer is unknown, contact the Customer Assistance Center.

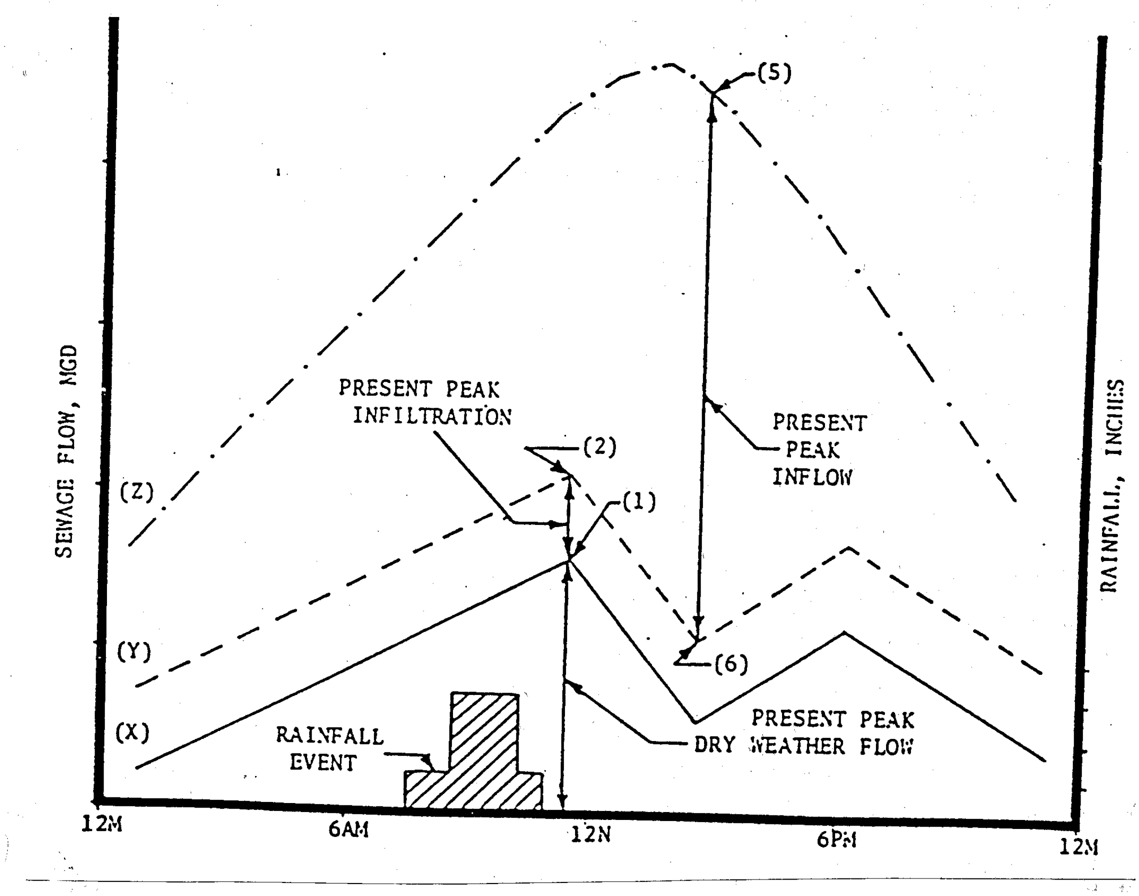
Customer Assistance Center .... (651) 297- 2274

MPCA .... (651) 296-6300

Toll-free .... (800) 657-3864

TTY... (651) 282-5332

Figure 1: Determination of Peak Hourly Flows Before Adjustment for Storm Event



Note: All flow measurements taken at treatment plant with adjustments for bypasses, overflows, and emergency pumping.

Groundwater elevation in relation to sewers should be stated for several points in the sewer system.

Dates of flow measurement should be stated.

PROJECT NAME ______________________________
LOCATION ______________________________
COMPLETED BY ______________________________ **DATE** ______________

Table 2: Determination of Design Flows

(A) For determination of peak hourly wet weather design flows (PHWW): Gallons Per Day

1	Present peak hourly dry weather flow	
2	Present peak hourly flow during high ground water period (no runoff)	
3	Present peak hourly dry weather flow [same as (1)] -	
4	Present peak hourly infiltration =	
5	Present hourly flow during high ground water period and runoff at point of greatest distance between Curves Y and Z	
6	Present hourly flow during high ground water (no runoff) at same time of day as (5) measurement -	
7	Present peak hourly inflow =	
8	Present peak hourly inflow adjusted for a 5-year 1-hour rainfall event	
9	Present peak hourly infiltration [same as (4)]	
10	Peak hourly infiltration cost effective to eliminate -	
11	Peak hourly infiltration after rehabilitation (where rehabilitation is cost effective) =	
12	Present peak hourly adjusted inflow [same as (8)]	
13	Peak hourly inflow cost effective to eliminate -	
14	Peak hourly inflow after rehabilitation (where rehabilitation is cost effective) =	
15	Population increase _______@_______ gpcd times 2.5 (peaking factor)	
16	Peak hourly flow from planned industrial increase	
17	Estimated peak hourly flow from future unidentified industries	
18	Peak hourly flow from other future increases	
19	Peak hourly wet weather design flow [(1)+(11)+(14)+(15)+(16)+(17)+(18)]	

(B) For determination of peak instantaneous wet weather design flow (PIWW): Gallons Per Day

20	Peak hourly wet weather design flow [same as (19)]	
21	Present peak hourly inflow adjusted for a 5-year 1-hour rainfall event [same as (8)] -	
22	Present peak inflow adjusted for a 25-year 1-hour rainfall event +	
23	Peak instantaneous wet weather design flow =	

(C) For determination of average dry weather design flow (ADW): Gallons Per Day

24	Present average dry weather flow	
25	Population increase _______@_______ gpcd	
26	Average flow from planned industrial increase +	
27	Estimated average flow from other future unidentified industries +	
28	Average flow from other future increases +	
29	Average dry weather design flow [(24)+(25)+(26)+(27)+(28)] =	

(D) For determination of average wet weather design flow (30-day average for mechanical plants and 180-day average for controlled discharge ponds) (AWW): Gallons Per Day

30	Present average dry weather flow	
31	Average infiltration after rehabilitation (where rehabilitation is cost effective) +	
32	Average inflow after rehabilitation (where rehabilitation is cost effective) +	
33	Population increase @ gpcd +	
34	Average flow from planned industrial increase +	
35	Estimated average flow from other future unidentified industries +	
36	Average flow from other future increases +	
37	Average wet weather design flow [(30)+(31)+(32)+(33)+(34)+(35)+(36)] =	

(E) Critical data (including a graphical display similar to Figure 1), methodology, and a discussion on the following items shall be included with the above calculations:

38	Dates during which actual flow data was recorded and its probable degree of accuracy.
39	Ground water elevation data relative to the collection system, during the time period when flow data was recorded.
40	Rainfall data during the time period when flow data was recorded and how the amount of rainfall compares to normal seasons.
41	Probable degree of accuracy of flow reduction due to proposed or completed I/I correction or elimination of bypasses.

Table 3: Essential Project Components Percentage

Definitions:

"Essential project components" means those components of a wastewater disposal system that are necessary to convey or treat a municipality's existing wastewater flows and loadings and future flows and loadings based on the projected residential growth of the municipality for a 20-year period.

Mass Loading (lbs./day) = Flow (MGD) X Concentration (mg/l) X 8.34

	Total Existing Daily Conditions		Total Proposed 20-year Design Conditions	
Flow (MGD)		MGD		MGD
$CBOD_5$ (mg/l)		mg/l		mg/l
Mass Loading (lbs./day)		lbs./day		lbs./day

Essential Project Components Percentage = 100 X $\frac{\text{Total Existing } CBOD_5 \text{ Mass Loading}}{\text{Total 20-year Growth Mass Loading}}$

= 100 X $\frac{(\quad)}{(\quad)}$

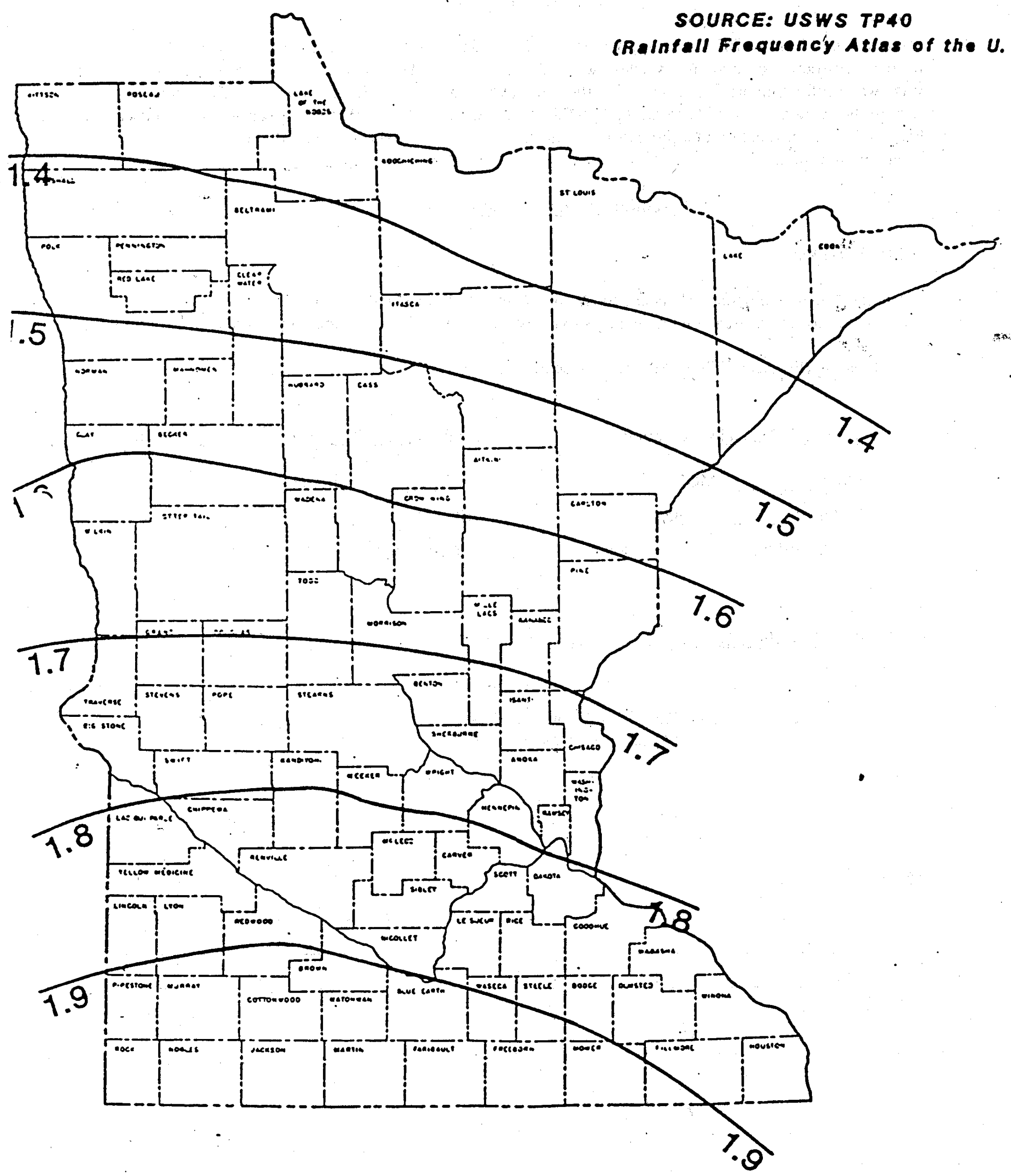
= _____%

Table 4: Determination of Design Loadings

		Unit Basis	ADW	AWW
Residential Waste	Population			
	Flow, GPD			
	BOD_5, #/day			
	TSS, #/day			
	NH_3-N, #/day			
	P, #/day			
Out-of-Town Students and Workers	Number			
	Flow, GPD			
	BOD_5, #/day			
	TSS, #/day			
	NH_3-N, #/day			
	P, #/day			
Seasonal Residents	Number			
	Flow, GPD			
	BOD_5, #/day			
	TSS, #/day			
	NH_3-N, #/day			
	P, #/day			
Industrial	Flow, GPD			
	Rated Flow, GPD			
	BOD_5, #/day			
	TSS, #/day			
	NH_3-N, #/day			
	P, #/day			
Other (Specify)	Flow, GPD			
	Rated Flow, GPD			
	BOD_5, #/day			
	TSS, #/day			
	NH_3-N, #/day			
	P, #/day			
Infiltration	GPD			
Inflow	GPD			
Total	Flow, GPD			
	Rated Flow, GPD			
	BOD_5, mg/l			
	BOD_5, #/day			
	TSS, mg/l			
	TSS, #/day			
	NH_3-N, mg/l			
	NH_3-N, #/day			
	P, mg/l			
	P, #/day			

* It may be necessary to also test for TKN for certain industrial contributors.

MAP NUMBER 1:
5-Year, 1-Hour Storm Event (inches)



MAP NUMBER 2 :
25-YEAR, 1-Hour Storm Event (inches)