Sewage Disposal at Middletown

by

Thomas F. Bowe
Consulting Engineer, New York

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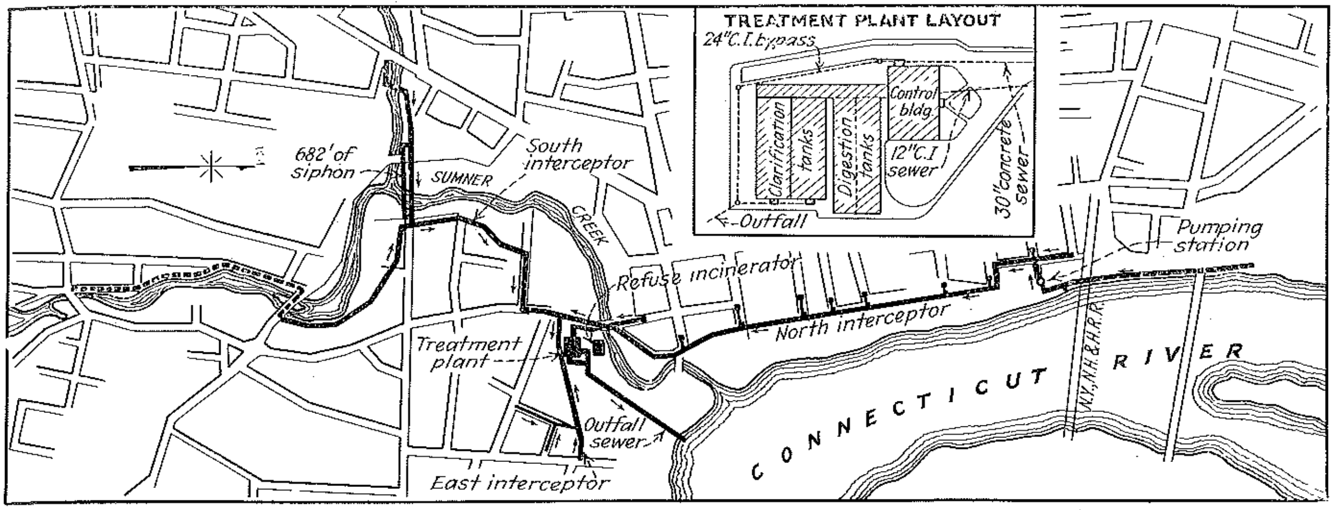

FIG. I. LOCATION PLAN OF INTERCEPTING SEWERS AND GENERAL LAYOUT OF SEWAGE DISPOSAL PLANT

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Connecticut community enlarges sewer system and builds a primary disposal plant featuring latest mechanical aids in treatment

Mechanical devices play an important role in the sewage treatment plant recently completed at Middletown, Conn. From grit handling to final sludge disposal by incineration, the new plant incorporates many types of new equipment to promote disposal efficiency and ease of operation.

Designed for a flow of 3 m.g.d., the plant provides sedimentation, separate sludge digestion in rectangular tanks, vacuum dewatering, and incineration in a multiple hearth furnace. Improvements made in the sewer system at the same time included the construction of a pumping station and 3.5 mi. of interceptors.

Middletown, with a population of 24,500, is located in the central portion of the state, on the west bank of the Connecticut River, about thirty miles from Long Island Sound. Previous to operation of the present plant, the majority of sewers were discharging their flow without treatment to the Connecticut River or its tributaries, through 16 outlets. A small portion of the sewage is treated by an Imhoff tank installation.

The design of intercepting sewers was prepared to direct most of the city's sewage to the treatment units without pumping. This was complicated by the need of placing pipe lines and plant above normal flood levels of the river. The various outlets were intercepted by three main branch sewers known as the North, South, and East interceptors.

North Interceptor—This is the main sewer paralleling the river and it serves the more developed section of the city wherein combined sewers exist. It is about 7,700 ft. in length, and is routed across Sumner Creek on a two-span steel bridge. Provision was made to by-pass storm flows in excess of maximum hourly sanitary sewage volumes, by the construction of ten regulator chambers.

The regulators consist of an adjustable float and gate arrangement, the gate being of the reverse Taintor type. The float chamber is connected with the interceptor and volume discharges are controlled by the depth of flow in the sewer.

Sewage from the northerly end of the city is directed to the interceptor by a small pumping station. This is equipped with duplicate centrifugal pumps of the vertical type, electrically driven, and with a rated capacity of 750 g.p.m. each, against a total head of 30 ft. Operation of the station is entirely automatic, control being exercised with float switches and automatic alternators.

South Interceptor—This sewer is 10,000 ft. in length, and includes two bridged stream crossings, and a siphon which conveys sewage across a valley. A feature of the siphon design is an arrangement whereby sewage may be drained from the lower siphon chamber to an existing low level sewer.

East Interceptor—This sewer involved the installation of 10,000 ft. of cast iron pipe line across the meadow on wooden pile bents. Subsequently, fill was placed up to and around the pipe. Suitable arrangements were necessary to maintain cross surface drainage from the inland side during low river stages, and toward the inland side at flood stages, since the earthwork was not designed to serve as a dam.

Both steel and cast iron pipe were used on the bridge crossings. The

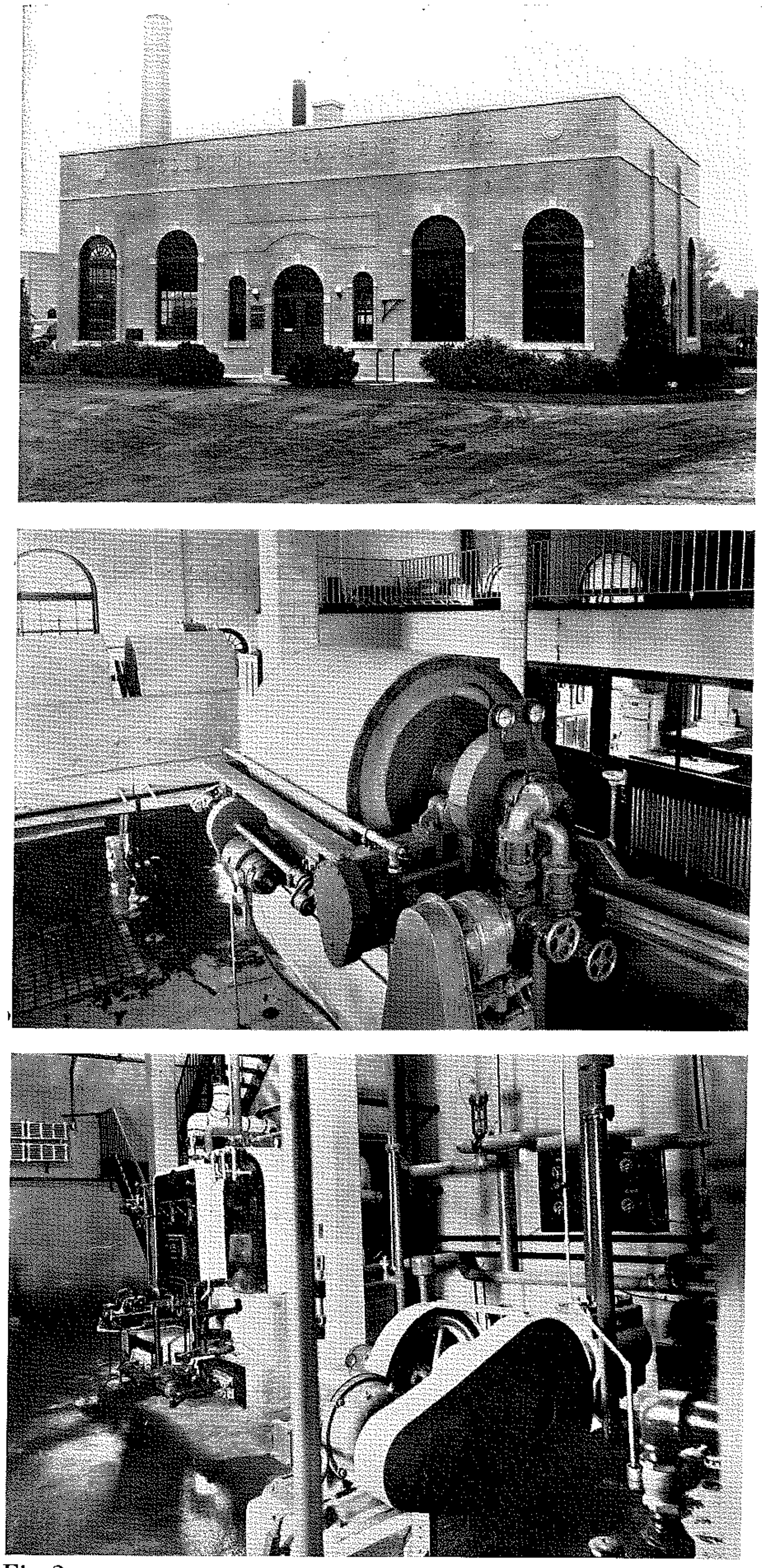

Fig. 2. Housed in the control building (top) is the principal mechanical equipment. The center picture shows the combination grit and screening collectors, vacuum sludge filter, and laboratory facilities. The bottom view shows the filter appurtenances and hot water boilers in the basement.

pipe is supported by piles, which includes half of the outfall line as well as the East interceptor, is of cast iron. The balance of the system is of vitrified and reinforced concrete pipe, the latter being used for sizes 24 in. and larger. Reinforced concrete pipe is surfaced on the interior with a bituminous material.

Pile foundations used

The treatment works are located almost midway between the north and south boundary lines of the city, about 1,100 ft. from the Connecticut River. The site is low-lying meadow land, adjacent to Sumner Creek. Overlying foundation material consists of alluvial deposits of silt, sand, and clay, and it was necessary to support all structures on pile foundations. Cast-in-place concrete piles, driven to an average depth of 33 ft., were used for the plant structure. Timber pile bents were used to support the influent and effluent sewers. Bearing capacities of piles were determined by a continuous driving record on each pile, and by static load tests applied to selected piles.

In addition to their primary duty of load bearing, the piles will also serve to resist hydraulic uplift action, incidental to annual high flood waters. Basement walls and floors of the buildings are designed to withstand water pressures of 26 ft., corresponding to the all-time high flood record in March, 1936.

Treatment plant design

Investigation of Middletown's sewage, and of the river flow and dilution, indicated that primary treatment would suffice. The various units are designed for an anticipated flow in 1946 of 3 m.g.d. This corresponds to a flow of 113 gallons per capita, for an estimated serviced population of 26,500 persons, and includes domestic, commercial, and industrial wastes, as well as a reasonable allowance for infiltration.

Sewage from the interceptors converges at a junction chamber and passes to duplicate mechanically-cleaned combination grit and screen chambers housed in the control building. Adjustable baffles provide for an average velocity through the grit chamber of 1 ft. per sec. The bar racks have clear openings of 1 in.; operation of the rakes and buckets is automatic and intermittent by means of time relay switches, with settings from 33 sec. to 33 min. Grit and screenings are discharged to a covered inspection chute and, after sorting, are directed to the sludge incinerator by means of a belt conveyor. This conveyor is also used for transporting sludge cake which has been filtered.

Following the grit and screen chambers, the sewage flow is directed through a 9x18 in. venturi tube, to either or both of two clarification tanks arranged to operate in parallel. The flow meter, located on the ground floor of the control building, provides a continuous and totalized record of the sewage passing through the plant.

A pipe gallery, extending along the southerly end of the tanks, contains all piping and control valves for delivery of sludge and sewage to and from tanks. Sidewalk-type lights provide adequate illumination for this water-tight chamber, and valves and meter tube can be readily serviced. The vent for gallery is carried above flood levels of the river.

Clarification tanks are of the rectangular longitudinal flow type. Each unit is 75 by 25 ft., with an average water depth of 9 ft.; the detention period is 2 hr., based on design flow. Each tank is equipped with two rows of chain and flight type collectors, which draw the settled solids to the influent end. At this point, cross-collectors are provided to further collect and concentrate the sludge before withdrawal.

The flights are arranged to collect floating matter on their upper return travel. Full width skimming is effected by construction of concrete shoulders at the water line, leaving a minimum of clearance between wall and flights. The scum so collected is placed in a receiving trough, drains to sludge pumps, and is delivered to digestors.

The effluent from the clarifiers is discharged into the river through a 24 in. c.i. outfall sewer.

Rectangular digestion tanks

The digestion tanks are rectangular in shape, 16 ft. wide, 85.25 ft. long, and have a depth of 16 ft. These units, with a combined volume of 41,780 cu.ft., will provide 60 days detention.

Each unit is equipped with all-

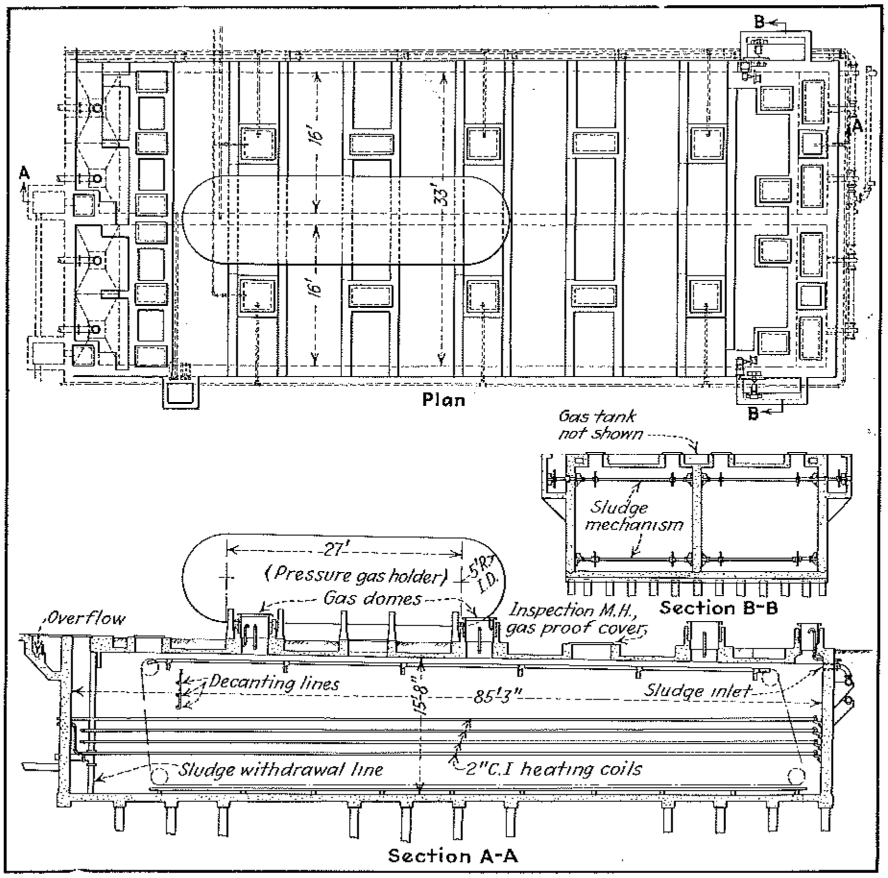

Fig. 3. Design details of rectangular sludge digestion tanks.

steel sludge collectors and scum breakers. These consist of channel-shaped cross flights, mounted at 10 ft. intervals on endless chains. Diagonal fins and manganese steel wearing shoes are attached to the flights, the latter sliding on abrasion resisting flats at both the upper and lower runs. The diagonal fins are arranged to move sludge alternately to the left and right as well as forward and, in this manner, thoroughly mix the sludge.

Concentrated digested sludge is ultimately deposited in deep hoppers, at the influent end of tanks. The speed of the chains is 2 ft. per min., and equipment is operated about 4 hr. per day. Collector chains are kept taut and free of excess stresses by means of cables, pulleys, and counterweights, mounted above the tanks.

The digestion tanks are equipped with six gas collecting domes, having a 12 in. water seal. To circulate hot water through the digestors for the maintenance of an 83 deg. F. temperature, 2-in. c.i. pipe coils are used; these provide 750 sq.ft. of heating surface. A cylindrical 2,650-cu.ft. steel tank, mounted on top of the digestors, is used to store excess gas under a pressure of 25 lb.

Sludge from the clarification tanks is pumped to the digestion tanks, the pumping being alternated between digestors on successive days. Supernatant liquor is returned to the influent sewage. All tanks and channels containing sludge or sewage are surface-proofed with a bituminous material.

Control building features

All other appurtenances utilized in treating the sewage are housed in the control building, which measures 36x55 ft. in plan. The sludge incinerator occupies a wing of the structure, and is separated from the remainder of the building by a dividing wall. The incinerator is located in the basement, and is charged by a screw conveyor located on the ground floor. Gas apparatus, including flame trap and meter, has been installed adjacent to the incinerator.

Equipment located in the main basement of the building includes two sludge pumps; duplicate sludge conditioning tanks; hot water boiler for digestion tank heating; a steam

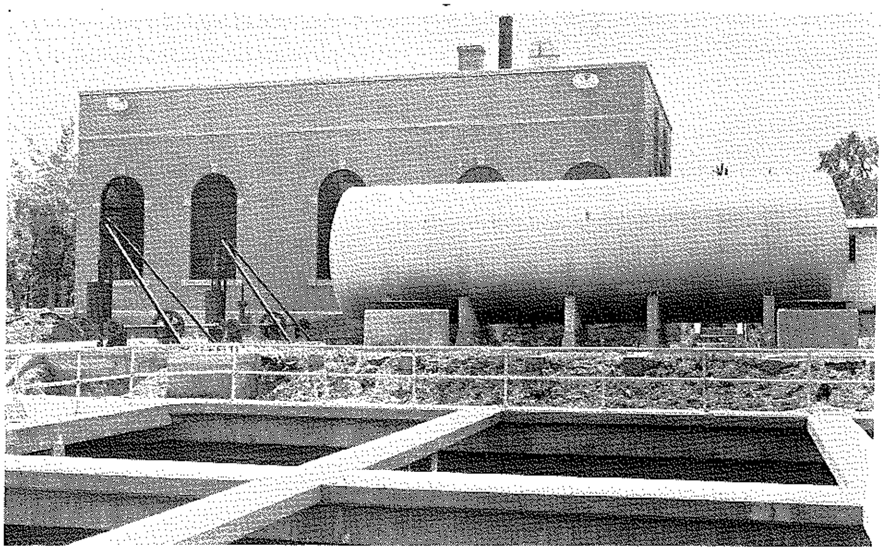

Fig. 4. Gas storage tank with a capacity of 2,650 cu.ft. mounted over the underground digestion tanks. Excess gas will be stored under a pressure of 25 lb.

plant for the building; various appurtenances necessary for the operation of the vacuum filter; and a gas compressor.

The ground floor contains the vacuum filter, with belt conveyor, the grit and screen mechanisms, and the main switchboard panels. Also located on this floor, in steel-glass enclosures, are the office, laboratory, and chemical feed and storage room. A balcony has been constructed above these rooms for storage of equipment and possible chemicals, if it is found advisable to purchase the latter in quantities greater than truckload lots.

Located directly under the chemical storage room are the sludge conditioning tanks, where lime and ferric chloride are added. Sludge is conditioned in batches, being mixed with horizontal shaft paddles, and pumped to the filter pan on the ground floor. The vacuum filter is of the continuous rotary drum type, with a net area of 96 sq.ft., and is guaranteed to produce three pounds of solids (dry weight) per square foot of filter area per hour. Filter cake is discharged directly to a belt conveyor; the filtrate liquor is returned to the influent sewage by gravity.

Sludge cake is conveyed by the belt either to the variable speed screw conveyor feeding the incinerator, or to storage piles on the charging room floor when the incinerator is not operating. Although the digested sludge cake is anticipated to be of a uniform nature, the variable speed feature on the screw conveyor provides a convenient control of the rate of feeding to the incinerator, should any variation occur in the moisture or volatile content of the cake.

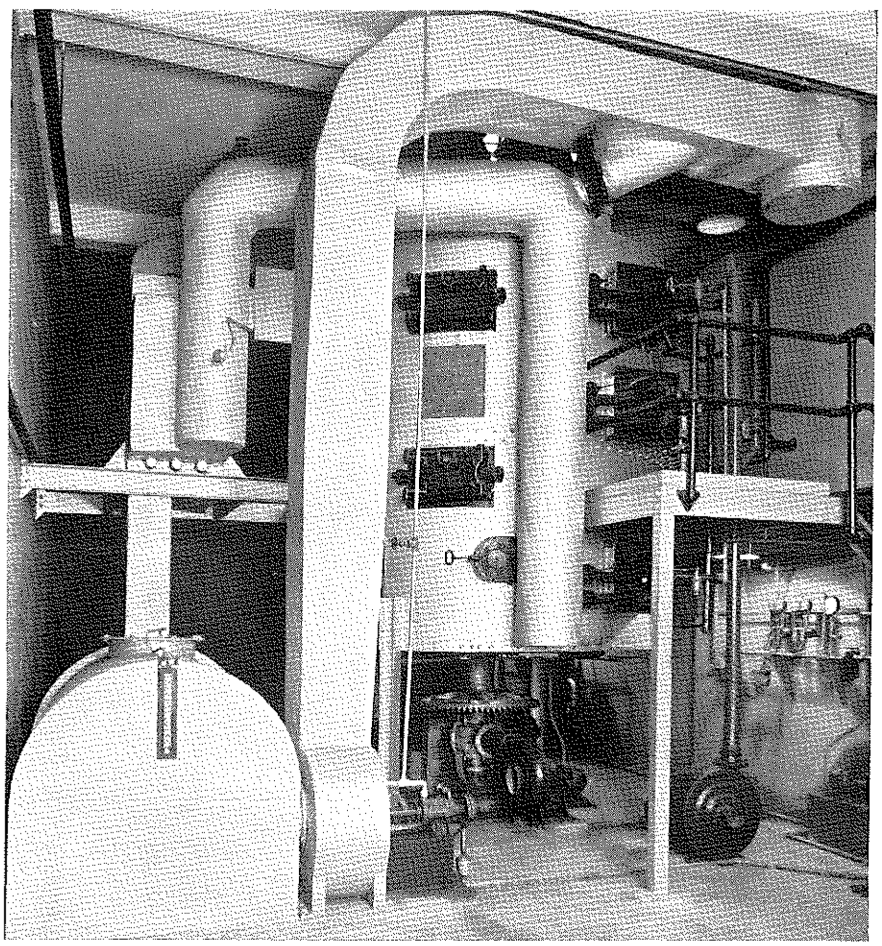

Fig. 5. Sludge incinerator of the multiple hearth type. At the left are the dust collectors and pre-heater.

Multiple-hearth incinerator

The sludge incinerator is of the multiple-hearth type, 9.25 ft. in diameter, with four hearths. It is guaranteed to convert to an inert ash, one ton of dry sewage solids in 8 hr. without creating any smoke or odor nuisance. The guarantee is based on burning a sludge cake containing not in excess of 75 per cent moisture, and with a heat value of 4,000 B.t.u. per lb. of dry solids. Sludge passing through the unit is subjected to a temperature of 1200 deg. F.

Ash discharges at the bottom of the unit, and is elevated by bucket conveyor to an ash hopper, located at the ceiling of the charging room; an enclosed steel chute conveys the ash outside of the building at truck loading height, and is disposed of by filling about the site.

The plant is designed to utilize the combustible gases evolved as a by-product of sludge digestion. Both heating units are provided with duplicate burners, while the sludge incinerator is equipped with combination burners to use either digestor gas or fuel oil, the latter being for stand-by purposes.

The gas system consists of collection domes in the roof of the digestors, a gas compressor, the gas storage tank, and a flame trap. The compressor is automatically controlled by a mercoid switch, set to start at 4 in. water pressure in the gas domes, and stop when this pressure is reduced to zero inches. The storage tank is provided with pressure relief valve, releasing at a tank pressure of 28 lb. per sq.in. A pressure reducing valve, installed between the storage tank and gas washer, reduces the gas pressure entering the washer and flame trap to 8 in. water pressure. A bypass line permits utilization of the gas directly from the digestion tanks. This line is also used to return gas to the sealed digestors while withdrawing sludge, thereby preventing the formation of a vacuum and breaking of the gas dome seals.

Operating results

While it is yet too early to outline any detailed data on operating results the following comments may be of interest.

The flow through the plant has shown considerable seasonal variation since sewage was admitted in March, 1937. In that month, the flow averaged 2.52 m.g.d.; in April, 2.25; and in May, 1.53 m.g.d. During the summer months of June, July, and August, the flow to the plant has averaged 1.07 m.g.d. Primary treatment has resulted in an average reduction in settleable solids of about 95 per cent, and a reduction of the suspended solids of 50 per cent.

Lime was added to digestors during the first few weeks of operation; thereafter the tanks maintained a pH of 6.9 to 7.1, without further control. Heating water has been circulated through the tank coils for 4 to 6 hr. each day, to maintain tank temperatures of 83 to 85 deg. F. Gasification is proceeding satisfactorily, and it is anticipated on the basis of present conditions, that sufficient gas will be available shortly for all intended purposes.

Results of operation of the vacuum filter have been highly satisfactory. Rates as high as 8 lb. of dry solids per sq.ft. of filter area per hr. have been obtained. Sludge delivered from the digestors has a solids content of 13 to 15 per cent. As previously noted, lime and ferric chloride are employed as coagulating chemicals; 6 to 8 per cent lime, and 2 to 3 per cent ferric chloride have been found suitable for this sludge. When so conditioned, the solids content of the filter cake averages 40 per cent; in no case has it fallen below 35 per cent, and on at least one occasion, it has been as high as 46.5 per cent. The performance test on the incinerator was not completed at the time of this writing.

The design of sewers and treatment works was executed by the writer serving as consulting engineer. Construction was supervised by the personnel of the Department of Public Works of Middletown, Samuel C. Cannon, superintendent, and Richard E. Mylchreest, chairman of the board. The treatment plant was built by the Suburban Engineering Co., New York. The job was financed in part with PWA grant.

Acknowledgment is made to John G. Albertson, the writer's associate, and Charles E. Potts, Jr., of his staff, for assistance in the preparation of this article.

Pipe	Cost
6"	27¢
8"	42¢
10"	63¢
12"	81¢
15"	108¢

Standard Pipe 40% off

Pipe	Cost
15"	1.80¢
18"	2.50
20"	3.00
21"	3.50
22"	4.00
24"	4.50
27"	6.50
30"	7.20
33"	9.00
36"	10.25

double strength pipe 35% off

Pipe manufactured in Standard Pipe up to 15" and from 15" upward in double strength only.

Feb. 25. 1944

Sewage from a population of 3000 flows to a pump well. Water elev. +10 above given datum, to be pumped to an elev. +60. The per cap sewage flow 80 g.p.d. Max 250% Min 50%

In addition ground water from 1.4 mile of sewer at 30,000 gals/day/mile.

Manuf. area 10 acres.

Required.

1. Compute storage volume of the pump well and design the pump so it will be started not oftener than once every 3 hours.
2. Required to determine the dimensions of the pump well and the drain, to equal the depth.
3. Determine the capacity of pumps if given and c.f.s. in their well, will be completed in one basis of 1 hour.
4. Required to estimate the [illegible] time to fill well and drain to the depth.
5. Required to determine the diam of the force main, through [illegible] of 1500 ft
6. Required to determine necessary H.P. Pump capacity of motor to ~~type of the H.W.~~ drive it at efficiency 80% pump

   Force main 1500 ft, motor efficiency 90%

   Max no. of K.W. delivered to pump motor

7. Estimate K.W. hours used per day.

Domestic

average Pumping Flow Domestic 80 x 2000 = 160,000 gals/day

Max Rate 2.5 x 160,000 = 400,000 gals/day

Min Rate .5 x 160,000 = 80,000 gals/day

Infiltration max = ave = min = 0.0225 mi = 35,000 gals/day (daily)

Industrial Waste

Max 10 x 15,000 = 150,000

Av 10 x 10,000 = 100,000

Min 10 x 5,000 = 50,000

Max Flow

400,000
35,000
150,000
585,000 / 8 = 73,125 required cap.

(1) 13,000 / 7.5 = minimum pump capacity

(2) $V = \frac{\pi D^2}{4} \times D = \frac{\pi D^3}{4}$

$D = \sqrt[3]{\frac{10,000}{.7854}} = 23.3' = 23'4"$

225
15
1125
225
(3375) 3000

.12
.8
96

(3) Removal by pumping in 1 hr

$10,000 + \frac{10,000}{3} = 13,300$ cu. ft

13,300 x 7.5 = 100,000 gals in 1 hr

Capacity of Pumps = $\frac{100,000}{60}$ = 1670 gals/min

$\frac{1670}{7.481 \times 60}$ = 3.71 c.f.s.

4. Min Rate of Flow 80,000
35,000
50,000
165,000 g.p.d.

$\frac{75,000}{165,000} \times 24 = 10.9$ hours (limited)

Min Empty Time
assume Pump will empty tank in 0.9 hours

Volume = 75,000 + 165,000 x $\frac{.9}{24}$ = 81,180 gals

$\frac{81,000}{1670}$ = 49 min. to empty

PENN. CULVERT COMPANY NEW ENGLAND METAL CULVERT CO.

Assume 49.5

V = 15,000 + 165,000 × $\frac{49.5}{1440}$ = 90,560 = 46.2 min.

5. $d = \sqrt[3]{\frac{371}{4 \times .7854}}$ = 1.086′ = 13.032″ use 14″ pipe

6. Assume Force Main 2000′ long

Friction in Main .0075 × 2000 = 15′

Total Max Head: 60 − 10 + 15 + 23 − 3″ = 88.3′

H.P. = $\frac{Qh}{7.9}$ = $\frac{3.71 \times 88.3}{8.9}$ = 37.8 H.P. Output of Pump

H.P. Motor = $\frac{37.8}{.6 \times .9}$ = ~~69.1~~ ..

Max KW = 69.1 × .746 = 51.5 motor Cable

.9 × 51.5 = 46.35 K.W. delivered

46.35 × .5 = 23.175 .. .. .. Pump.

Tank empties 6 times in 24 hours

4.85 × 51.917 = 250 K.W. hr. per day

H.P. = $\frac{371 \times 17}{8.9}$ = 324 H.P. Average Head

K.W. hrs = 4.85 × 32.4 = 156 K.W. hrs Pump

$\frac{106}{.54}$ = 196 K.W. Hours

245,000 × $\frac{62.5}{7.5}$ = 2,460,000 #

$\frac{2,460,000 \#}{33,000 \times 60 \times .54}$ = ~~1317~~ K.W. hours Average head.

QUANTITIES

of JUTE, ~~G-K PRIMER~~ and G-K SEWER JOINT COMPOUND Required Per Joint for Connecting A. S. T. M. Standard Vitrified Pipe.

Size of Pipe	Pounds Jute	Pounds G-K Compound
4"	.03	.52
6"	.04	1.22
8"	.15	1.98
10"	.26	2.42
12"	.31	3.07
15"	.40	3.5
18"	.47	5.31
21"	.65	7.59
24"	.74	8.58
27"	1.29	12.87
30"	1.65	15.9
33"	1.76	19.5
36"	2.44	28.8

This calculation is based on 10% excess for possible waste.

TELEPHONE
LIBERTY 0940

ENGINEERING STAFF
PAUL D. SARGENT
HARRY E. COTTON
MILTON J. ADAMS

CORRUGATED METAL PIPE
MANUFACTURER'S ASSOCIATION
OF NEW ENGLAND
1417 STATLER BUILDING
BOSTON, MASS.

March 15, 1935

Mr. Norman Germaine,
Asst. City Engineer,
Middletown, Conn.

Dear Mr. Germaine:

Mr. Ryan, of the Berger Metal Culvert Company, has asked us to send you information regarding the value of "n" in Kutter's formula.

CHEZY FORMULA

In 1775 Chezy developed a formula for determining the flow of water in open channels and pipes which has been in general use and is written as follows:

$$V = c\sqrt{RS} \qquad Q = A\ V \quad \text{and} \quad Q = A\ c\sqrt{RS}$$

in which:

Q = discharge in cu. ft. per sec.
A = cross-sectional area of flow in sq. ft.
V = mean velocity of water, in feet per sec.
c = a coefficient of roughness whose value depends upon the character of surface over which water is flowing.

$$R = \text{mean hydraulic radius in ft.} = \frac{\text{area of section}}{\text{wetted perimeter}}$$

S = slope, or grade, in feet per foot

This is a fundamental formula, and is the basis of most capacity formulas.

KUTTER'S FORMULA:

Thousands of experiments have been made to determine the value of c to be used in above equation, and a large number of such experiments were made by two Swiss engineers, Ganguillet and Kutter, which resulted in the following formula, commonly called Kutter's formula:

$$c = \frac{41.65 + \frac{.00281}{S} + \frac{1.811}{n}}{1 + \frac{n}{\sqrt{R}}\left(41.65 + \frac{.00281}{S}\right)}$$

in which:

S = slope in ft. per foot
R = hydraulic radius in ft.
n = coefficient of roughness.

VALUE OF n

The factor, "n", in both the Kutter and Manning formula, is intended to be a measure of the effect of roughness; not only of skin or sliding friction but of all other retarding influences as well, once the water is inside the pipe. It does not include losses of head which may be incurred in entrance or exit and hence leaves out of account an important phase in the hydraulic cycle of subsurface flow.

Selection of the proper value of "n" to use in a specific case depends upon the exercise of trained judgment after careful consideration of all data relating to similar conditions. If no data of comparable conditions exist the choice of "n" becomes little more than scientific guesswork. Under such circumstances an assumed value of "n" may fail to represent actual flow conditions by a wide margin. Much more research is required before greater accuracy can be obtained. At present the best that can be done is to record the average values in current use among conservative engineers.

Values of "n" for Sewers

n = .012 for unplaned lumber and ordinary iron pipe
n = .013 for concrete and vitrified clay pipe with good alignment
n = .015 for ordinary brick work
n = .020 for corrugated metal
n = .025 for canals and rivers in good condition

The above value of "n" for corrugated pipe to be used in the Kutter formula, was arrived at as follows:

SOURCE	Measured Value of Kutter's "n"
Flow tests of storm sewer at El Paso, Texas, 1037.8 ft. pipe on tangent, 24" diameter service conditions (Eng. N-R, 4-17-13)-	.0199
Iowa Flow Tests, University of Iowa Bulletin No. 1, Series 103, p.55. Average of four sizes, 12", 18", 24", 30", 30 feet long, laboratory conditions- - - - - - - - - - - - -	.0215
Arlington Flow tests by U.S. Bureau of Public Roads, average of two sizes, 8" and 10", 200 ft. long, laboratory conditions, (Eng. N.R., 3-2-22, P.352)- - - - - - - - - - - - - - - - -	.0190
Average of all authorities	.0201

The above tests were made on galvanized corrugated pipe. There have been no tests made for coated corrugated pipe as specified by the State Highway Department of Connecticut for culverts. No doubt, the asphalt coating will reduce the value of "n" to something like 0.19 or possibly 0.17. 0.019 & 0.017

I expect to be in Middletown next week, about Wednesday, and will be very glad to discuss this subject further with you.

Very truly yours,

CORRUGATED METAL PIPE ASS'N. OF N.E.

By H. E. Cotton

HEC
eh

New Haven, Conn.

Mr. C. J. Doherty meteorologist — Received Jan 19, 1935

Form No. 1078 B—Met'l.

(WB—9-2-31—25,000)

U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU

Data, Rainfall intensity 1873 to 1934.

~~Stations~~	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	~~Annual~~ Max
5 min	.20	.23	.28	.20	.41	.43	.84	.67	.42	.25	.15	.27	.84
10 min	.31	.25	.31	.25	.60	.73	1.38	1.19	.77	.35	.19	.37	1.38
15 min	.37	.32	.35	.32	.68	.80	1.96	1.49	1.06	.39	.26	.45	1.96
30 min	.45	.47	.54	.45	.85	1.31	2.34	2.05	1.68	.66	40	.54	2.34
1 hour	.69	.74	.89	.71	.97	1.55	2.38	2.16	2.33	1.18	.67	.74	238
2 hours	1.25	1.01	1.04	1.32	1.38	1.93	2.40	2.67	2.55	1.70	.79	1.03	2.67
24 hours.	7.74	4.13	4.78	5.90	3.32	4.79	7.00	8.73	6.69	5.19	3.13	3.75	8.73

For Mr. L. Normain Germain
Asst. Supt.
~~Dept. of Public Works,~~
Middletown, Conn.

REMARKS.

Interceptor Design

The basis of design used should provide for one-half the cross section available at the end a twenty-five year period, or inclusive of the year 1956. Quantities used were as outlined under "Quantity of Sewage". The rates of discharge were 200 per cent of average daily domestic, 150 per cent of industrial, 200 per cent of average daily commercial rate, and wet weather infiltration from the anticipated mileage of sewers. The tabulation following, displays the estimated contributions from the various sources by zones for the yaer 1956.

In the allocation of population to the various zones, some duplication was anticipated in order to assure the adequacy of the interceptor at each point. The summation of population in this tabulation is in excess of the estimated total for that date. Either the North or South or both Interceptors should provide sufficient capacity for a more extended period than planned.

Interception and accumulation of flows from the various zones occur in various orders according to Plan A, B, or C. In Plan A (see Plate IX) the zones are cumulative in the numerical order D_1,D_2, etc., while in Plan B (see Plate X-- one pumping station) the interceptor flows northerly from Zone D_{14} to D_4 and southerly from Zone D_1 to $_4$ with a junction at the pumping station. From the station to the plant site, capacity is provided in the force main.

In Plan C (see Plate XI) with one pumping station, the North Interceptor is composed of two branches;one flowing Northerly serving Zones D_{12} and D_9 to D_4,inclusive, and lower portions of D_{10},D_{11} and D_{14}. The other branch flows southerly serving Zones D_1 to D_4, inclusive, both branches terminating at a pumping station from whence the flow is pumped to a high level line at College Street. From this point, the Interceptor collects Zone D_{10}, D_{11} , D_{13} and then D_{14}.

The South Interceptor is common to all plans. The order of accumulation is indicated in the following tabulation which represents Plan A.

PLAN A--INTERCEPTOR

ZONE	REQUIRED CAPACITY HALF FULL c.f.s.	REQUIRED CUMULATIVE CAPACITY--HALF FULL c.f.s.	SIZE	GRADIENT FEET PER HUNDRED
		North Branch		
D_1	1.67	1.67	18"	0.12
D_2	0.04	1.71	18"	0.12
D_3	0.23	1.94	18"	0.15
D_4	0.39	2.33	20"	0.12
D_5	0.13	2.46	20"	0.14
D_6	0.39	2.85	24"	0.08
D_7	0.01	2.86	24"	0.08
D_8	0.48	3.34	24"	0.09
D_9	0.14	3.48	24"	0.095
D_{10}	0.36	3.84	24"	0.12
D_{11}	0.50	4.34	27"	0.08
D_{12}	0.05	4.39	27"	0.08
D_{13}	0.52	4.91	27"	0.11
D_{14}	0.23	5.14	27"	0.12
D		South Interceptor		
D_{16}	2.60	2.60	15"	0.72
D_{15}	0.13	2.73	18"	0.30
		***********		
E_{1a}	0.66	0.66	10"	0.45
E_{1b}	0.15	0.81	10"	0.65
E_{1c}	0.89	2.70	15"	0.75
E_2	0.33	3.03	24"	0.08
D_{15-16}	2.73	5.76	27"	0.15

E_{3-4}	0.22	5.98	27"	0.155

East Interceptor

E_5	0.40	0.40	10"	0.29

These flows accumulate at the treatment plant site. In view of the time element, maximum flows will not prevail from all lines at the same time. The trunk line serving all interceptors is, therefore, designed for the above volumes when flowing two-thirds full, the summation of these flows being as follows:

		Required size and Gradient	
D_{1-14}	5.14 c.f.s.		
E_1 to 4, D_{15-16}	5.98		
E_5	0.40		
	11.52 c.f.s.	36"	0.07

The outfall line is capable of providing this capacity flowing full as a gravity force main. A 24" cast iron line under a head of two feet will discharge this flow against high water levels of 31.00 without backing up in the sewers.

ESTIMATED RATE OF DISCHARGE FROM VARIOUS ZONES

Zone	Net Area in Acres: Industrial	Net Area in Acres: Developed Industrial	Net Area in Acres: Commercial	Net Area in Acres: Residential	Length Sewers Feet	Infiltration 20,000 g.m.d.	Design Population	Domestic @ 100 g.c.d.	Industrial @150o/o of 24 hr. flow	Additional for Commercial	Total Estimated flow gals. day
D_1	90.25	48.00	2.66	69.53	17,450	60,100	3,675	367,500	648,000	4,500	1,080,100
D_2	1.11	-----	----	8.73	1,330	5,040	126	12,600	------	1,500	19,140
D_3	1.55	-----	5.46	12.18	4,620	17,500	1,242	124,200	------	10,500	152,200
D_4	0.74	0.33	6.86	22.26	4,956	18,800	2,010	201,000	4,455	31,500	255,755
D_5	1.56	-----	4.52	1.76	1,150	4,360	663	66,300	-----	15,000	85,680
D_6	0.99	-----	11.30	36.62	6,750	25,600	1,920	192,000	-----	39,000	256,000
D_7	0.61	-----	----	0.60	550	2,840	45	4,500	-----	-----	7,340
D_8	5.46	o.33	12.20	21.73	4,600	17,440	2,184	218,400	4,455	70,500	310,795
D_9	4.75	1.15	1.39	----	1,050	3,980	555	55,500	15,818	15,000	90,300
D_{10}	5.49	0.66	6.53	30.68	5.650	21,440	1,633	163,300	8,910	39,000	232,650
D_{11}	17.72	8.10	10.22	3.46	5,770	21,860	1,634	163,400	109,350	31,500	326,110
D_{12}	1.03	2.05	----	----	250	940	36	3.600	27,742	-----	32,285
D_{13}	6.42	4.50	2.37	44.97	8,400	31,860	2,276	227,600	60,750	18,000	338,210
D_{14}	5.29	0.57	0.47	20.81	4,410	16,700	1,135	113,500	7,695	10,500	148,395
D_{15}	1.54	----	0.56	27.02	3,977	15,080	702	70,200	----	1,500	86,780
D_{16}	9.69	15.00	18.80	3409.	73,675	279,000	11,945	1,194,500	202,500	10,500	686,500

Zone	Net Area in Acres				Length Sewers Feet	Infil-tration 20,000 g.m.d.	Design Popula-tion	Domestic @ 100 g.c.d.	Industrial @ 150% of 24 hr.flow	Addi-tional for Commer-cial	Total Estimated flow gals.day
E_1	73.78	63.00	2.36	540	45,000	170,500	7,295	729,500	850,500	6,000	1,756,500
E_2		1.50	2.25	89.50	8,725	33,050	1,516	151,600	20,250	7,500	212,400
E_3	3.94	----	1.65	36.80	1,125	4,260	796	79,600	------	6,000	132,795
E_4	2.93	2.55	----	12.70	2,250	8,460	796	79,600	34,425	6,000	132,795
E_5	55.10	11.40		18.30	3,900	14,790	848	84,800	153,900	3,000	256,440

Fig. 1 shows the annual precipitation for the period 1859-1933 together with the mean, median, upper and lower quartiles. During this period the precipitation was greater than the mean on 35 occasions and less than the mean on 40 occasions.

The first 45 years of the period 1859-1933 (i.e. 1859-1903) was wet while the last 30 years (i.e.1904-1933) was dry. During the former, the precipitation was greater than the mean on 27 occasions and less than the mean on 18 occasions. During the latter,the precipitation was greater than the mean on 8 occasions and less than the mean on 22 occasions.

Both the driest year (1846) and the wettest year (1901) occurred during the first 45 years of the period 1859 to 1903. A study of Fig. 1 reveals that the wet period is not made up of a succession of abnormally wet years, but rather that it is made up of a preponderance of years in which the precipitation is greater than the mean (in a few of which the precipitation is extremely great) together with a minority of years in which the precipitation is less than the mean (in a few of which the precipitation is extremely small). A similar study of Fig. 1 shows that the dry period is made up of a preponderance of years in which the precipitation is unusually small together with relatively few years in which the precipitation is in close proximity to the mean.

The arithmetic mean or average annual precipitation during the 45 year wet period, 1859-1933, is 49.17 inches This is 5.8% greater than the mean of the 75 year period. The mean annual precipitation during the 30 year dry period, 1904-1933, is 42.45 inches or 8.7% less than the mean of the 75 year period.

These deviations from the mean corroborate the general impression that dry periods diverge more from the mean than wet periods.

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that any inaccuracies arising from that source are offset by the fact that the long term record, as used, is probably more representative of the true precipitation than the short term record available at Mt. Higby. It will be shown subsequently that the 30 year record 1904-1933 is about 9% less than the average of the 75 year period. It is doubtful that the record at Middletown would fail to be representative of conditions at Mt. Higby by as wide a margin as 9%.

Therefore, on this basis, the policy followed in ~~continuing~~ combining the records taken at Middletown with those taken at Mt. Higby, 3 or 4 miles distant from Middletown, would seem to be justified.

The precipitation as recorded at Mt. Higby is measured daily at 12 o'clock noon. The guage is a cylindrical non-recording guage and the measurement is made by means of a graduated wd. Snowfall is measured, and the result recorded in the Department of Public Works record of meteorological observations as inches, of snowfall. It is then melted and measured again. This last when measured is recorded as precipitation. Thus it may be observed that the record of precipitation includes melted snow. The recorded observation at 12 o'clock noon is the precipitation for the 24 hour period preceding the time of observation. The observations are reported once a month to the Secretary of the Department of Public Works who enters the same in a bound volume kept for that purpose.

During the year 1895 the Board of Water Commissioners began certain studies in connection with the proposed construction of the Mt. Higby Reservoir and a study of the precipitation was included. For this purpose the records from 1859 to 1895 were tabulated and the mean for each month and the mean annual precipitation computed. These figures were presented in the annual report of the Board of Water Commissioners for the year 1895.

While great care has been exercised in taking and recording the observations, no effort has been made to compile or analyse the data since 1895. This is due no doubt, to the fact that Middletown enjoys an abundant supply of water for its present population.

The compilation of precipitation records, particularly when the records are allowed to accumulate, is a tedious task. In the hope of reducing the amount of work to be done at some future time, this study has been made. If the results hereinafter set forth prove to be sufficiently valuable, it is hoped that the observations at Mt. Higby will be continued in somewhat the form used herein, so that a continuos record will be available at almost a moment's notice.

HISTORICAL NOTE: The records, from which this study was made were observed and recorded from 1859 to June 1, 1868, inclusive, at Wesleyan University, under the direction of Prof. John Johnston; and from thence to 1892 at Middletown Cooperative Weather Station by H.D.A. Ward; and from thence to April 1, 1898 at the Middletown Cooperative Weather Station on South Main Street by Charles W. Hubbard; and from thence to April 1, 1899 at Mt. Higby Reservoir by J. W. Buck; and from thence to Nov. 1, 1913 at Mt. Higby Reservoir by Edwin Bywater; and from thence to date at Mt. Higby Reservoir by William J. Ackerman.

It may be argued, and properly so, that the records presented are not wholly those of the Mt. Higby Station because, in reality, only the last 35 years of the record was obtained at that station. It is assumed in this study that any inaccuracies arising from that source are offset by the fact that the long term record as used probably more representative of the true precipitation than the short term record available at Mt. Higby. It will be shown subsequently that the 30 year record 1904-1933 is about 9% less than the average of the 75 year period. It is doubtful that the record at Middletown would fail to be representative of conditions at Mt. Higby by as wide a margin as 9%.

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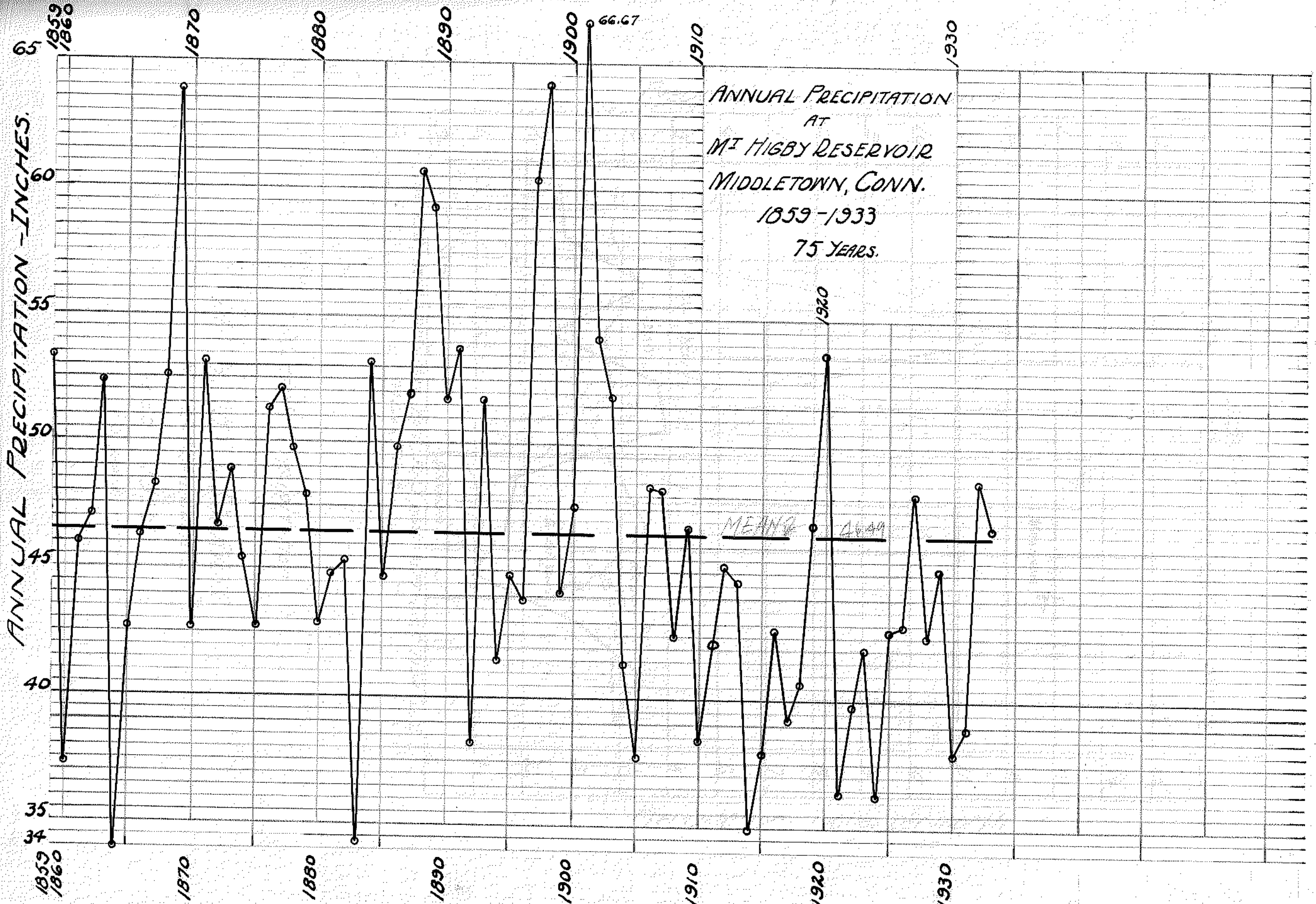
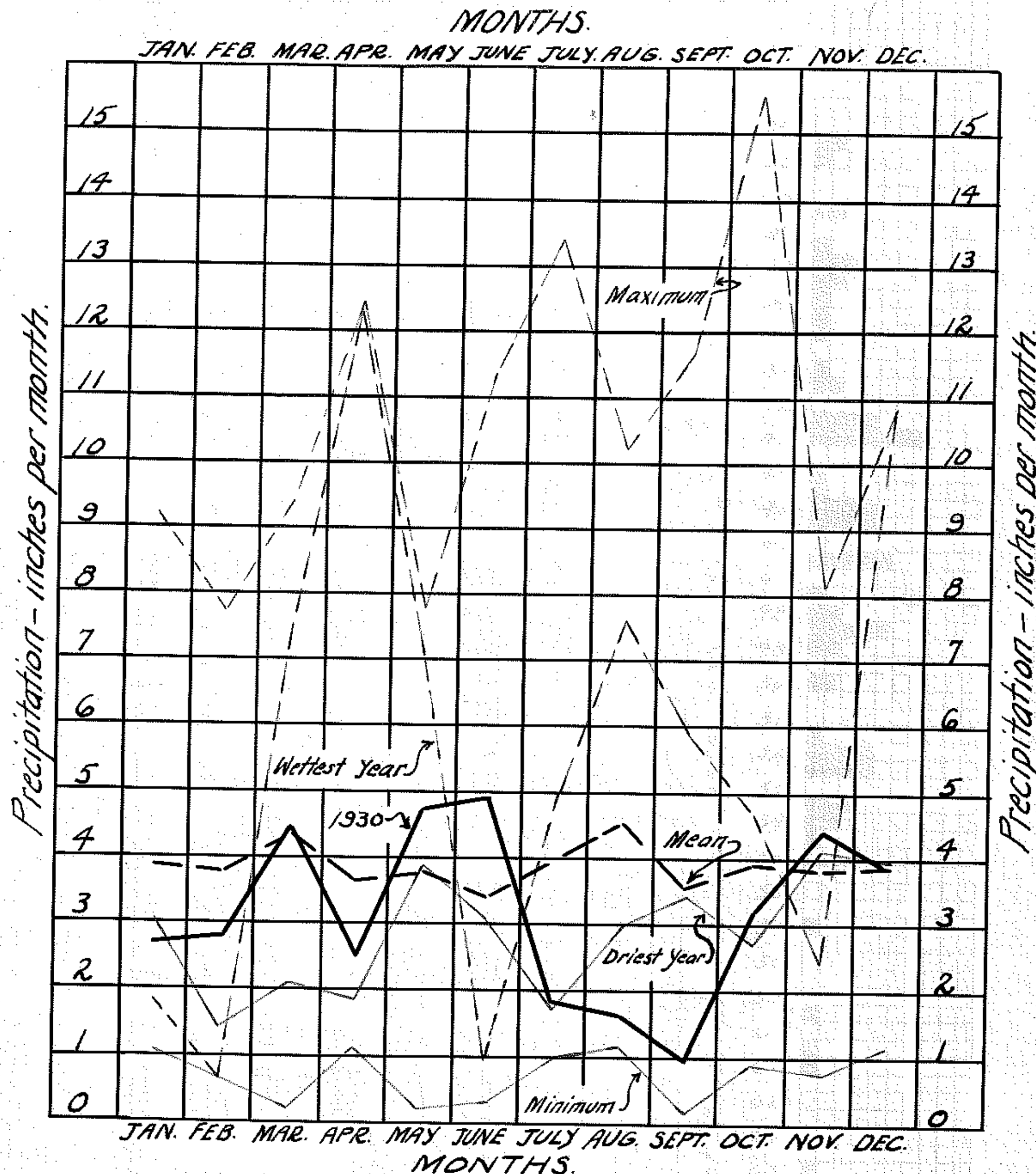
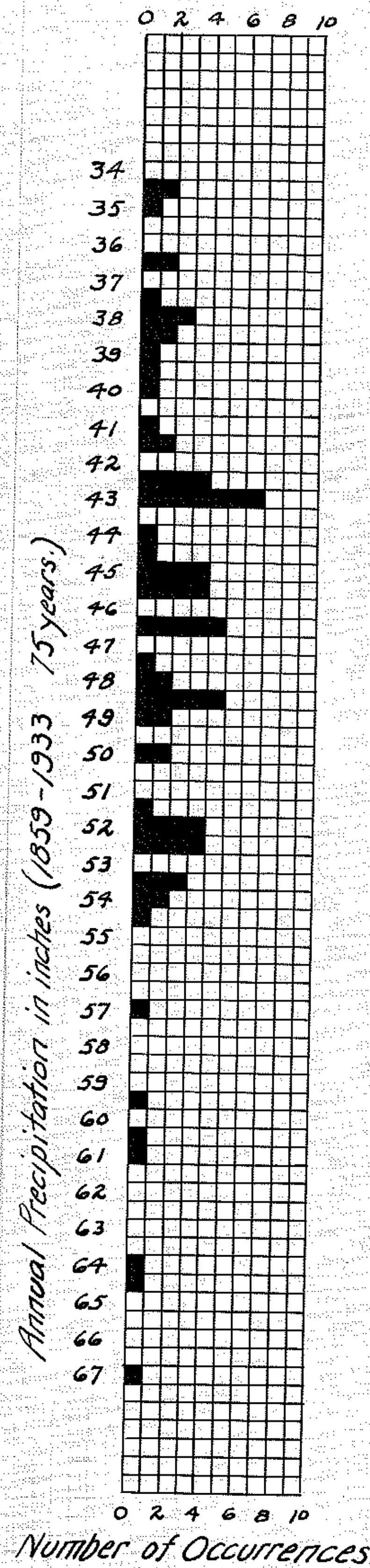
Fig I


ANNUAL PRECIPITATION
AT
MT HIGBY RESERVOIR
MIDDLETOWN, CONN.
1859-1933
75 YEARS.
ANNUAL PRECIPITATION - INCHES.
65
60
55
50
45
40
35
34
1859
1860
1870
1880
1890
1900
1910
1920
1930
66.67
MEAN



Monthly Precipitation
at
M^T HIGBY RESERVOIR
Middletown, Conn.
1859 - 1933
75 years.


0 2 4 6 8 10
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
Annual Precipitation in inches (1859-1933 75 years.)
0 2 4 6 8 10
Number of Occurrences.

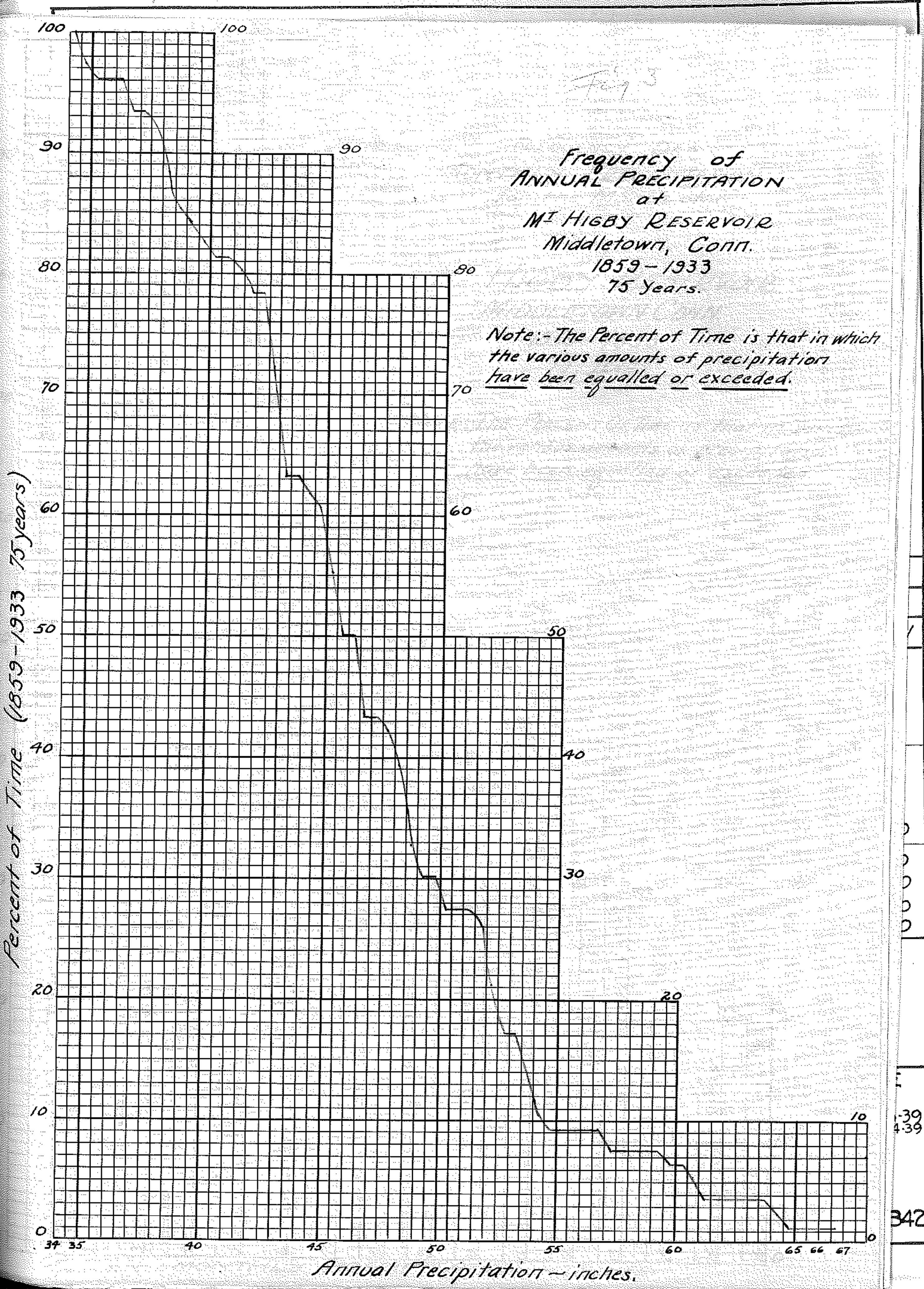
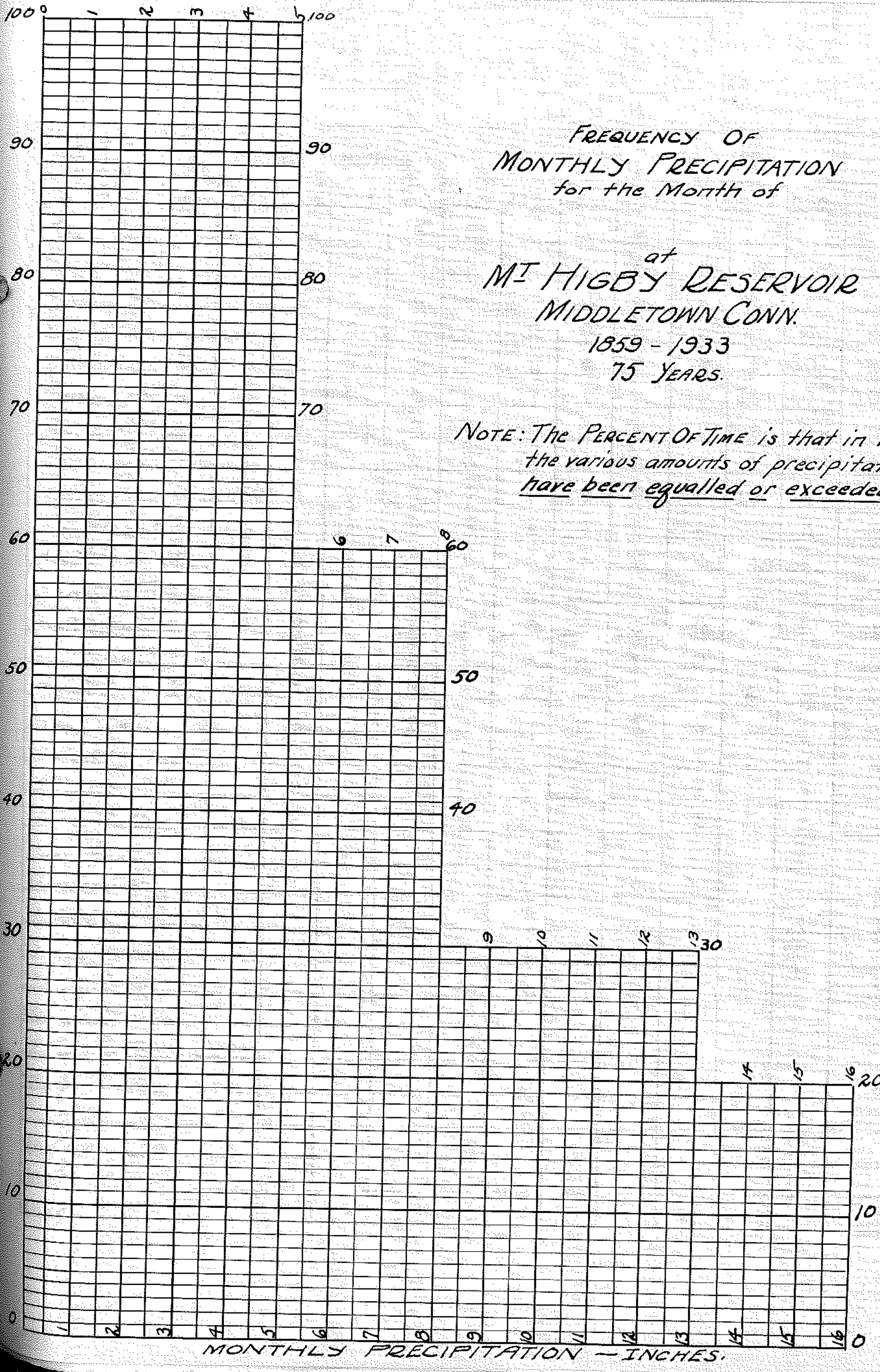


Fig 3
Frequency of ANNUAL PRECIPITATION at M^T HIGBY RESERVOIR Middletown, Conn. 1859 - 1933 75 Years.
Note:- The Percent of Time is that in which the various amounts of precipitation have been equalled or exceeded.
Percent of Time (1859-1933 75 years)
Annual Precipitation - inches.
100
90
80
70
60
50
40
30
20
10
0
34 35 40 45 50 55 60 65 66 67



FREQUENCY OF
MONTHLY PRECIPITATION
for the Month of

at
MT HIGBY RESERVOIR
MIDDLETOWN CONN.
1859 - 1933
75 YEARS.

NOTE: The PERCENT OF TIME is that in which the various amounts of precipitation <u>have</u> <u>been</u> <u>equalled</u> <u>or</u> <u>exceeded</u>.

Monthly Precipitation in inches	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec	Total
	NUMBER OF OCCURRENCES 1859-1933 75 Years												
0.00-0.49			1		3	3			2				9
0.50-0.99		2			2	2	1		5	2	5		19
1.00-1.49	2	5	4	4	4	5	4	6	3	10	1	1	49
1.50-1.99	6	7	5	9	5	7	9	6	8	5	8	5	80
2.00-2.49	10	5	2	7	5	9	9	4	13	5	6	10	85
2.50-2.99	9	9	10	8	7	6	11	4	9	10	10	10	103
3.00-3.49	11	7	7	16	8	12	5	5	3	7	9	8	98
3.50-3.99	7	7	8	7	7	9	4	4	10	6	1	15	85
4.00-4.49	6	10	6	9	7	6	9	8	2	7	10	6	86
4.50-4.99	4	3	7	4	7	3	4	9	5	5	4	3	58
5.00-5.49	4	8	4	2	7	5	5	5	3	4	4	6	57
5.50-5.99	10	3	5	4	1		4	5	3	3	5	4	47
6.00-6.49	1	3	2		5	4	3	4	2	2	4	3	33
6.50-6.99	2		4	1	3	1	2	4	1	2	3		23
7.00-7.49	2	2	1	2	2	1	1	3			4	1	19
7.50-7.99		3	4		2			2	3	2		2	18
8.00-9.49				1		1		3		1	1		7
8.50-8.99			2					2	1	1			6
9.00-9.49	1	1	3							1			6
9.50-9.99													
10.00-10.49							1	1	1	1			4
10.50-10.99												1	1
11.00-11.49						1	1						2
11.50-11.99									1				1
12.00-12.49				1									1
12.50-12.99													
13.00-13.49							2						2
13.50-13.99													
14.00-14.49													
14.50-14.99													
15.00-15.49										1			1

Monthly Precipitation in inches.	Percent of Time (1859 - 1933) (75 years) in which the Indicated amount of Monthly Precipitation has been equalled or exceeded.										
	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul	Aug	Sept	Oct.	Nov	Dec.
0.00-0.49	100	100	100	100	100	100	100	100	100	100	100	100
0.50-0.99	100	100	98.7	100	96	96	100	100	97.3	100	100	100
1.00-1.49	100	97.3	98.7	100	93.3	93.3	98.7	100	90.7	97.3	93.3	100
1.50-1.99	97.3	90.7	93.3	94.7	88	86.7	93.3	92	86.7	84	92	98.7
2.00-2.49	89.3	81.3	86.7	82.7	81.3	77.3	81.3	84	76	77.3	81.3	92
2.50-2.99	76	74.7	84	73.3	74.7	65.3	69.3	78.7	58.7	70.7	73.3	78.7
3.00-3.49	64	62.7	70.7	62.7	65.3	57.3	54.7	73.3	46.7	57.3	60	65.3
3.50-3.99	49.3	53.3	61.3	41.3	54.7	41.3	48	66.7	42.7	48	48	54.7
4.00-4.49	40	44	50.7	32	45.3	29.3	42.7	61.3	29.3	40	46.7	34.7
4.50-4.99	32	30.7	42.7	20	36	21.3	30.7	50.7	26.7	30.7	33.3	26.7
5.00-5.49	26.7	26.7	33.3	14.7	27.7	17.3	25.3	32	20	24	28	22.7
5.50-5.99	21.3	16	28	12	17.3	10.7	18.7	32	16	18.7	22.7	14.7
6.00-6.49	8	12	21.3	6.7	16	10.7	13.3	25.3	12	14.7	16	93
6.50-6.99	6.7	8	18.7	6.7	9.3	5.3	9.3	20	9.3	12	10.7	5.3
7.00-7.49	4	8	13.3	5.3	5.3	4	6.7	14.7	8	9.3	6.7	5.3
7.50-7.99	1.3	5.3	12	2.7	2.7	2.7	6.7	10.7	8	9.3	1.3	4
8.00-8.49	1.3	1.3	6.7	2.7	0	2.7	6.7	8	4	6.7	1.3	1.3
8.50-8.99	1.3	1.3	6.7	1.3	0	1.3	6.7	4	4	5.3	0	1.3
9.00-9.49	1.3	1.3	4	1.3	0	1.3	6.7	1.3	2.7	4	0	1.3
9.50-9.99	0	0	0	1.3	0	1.3	6.7	1.3	2.7	2.7	0	1.3
10.00-10.49	0	0	0	1.3	0	1.3	5.3	1.3	2.7	2.7	0	1.3
10.50-10.99	0	0	0	1.3	0	1.3	5.3	0	1.3	1.3	0	1.3
11.00-11.49	0	0	0	1.3	0	1.3	4	0	1.3	1.3	0	0
11.50-11.99	0	0	0	1.3	0	0	2.7	0	1.3	1.3	0	0
12.00-12.49	0	0	0	1.3	0	0	2.7	0	0	1.3	0	0
12.50-12.99	0	0	0	0	0	0	2.7	0	0	1.3	0	0
13.00-13.49	0	0	0	0	0	0	2.7	0	0	1.3	0	0
13.50-13.99	0	0	0	0	0	0	0	0	0	1.3	0	0
14.00-14.49	0	0	0	0	0	0	0	0	0	1.3	0	0
14.50-14.99	0	0	0	0	0	0	0	0	0	1.3	0	0
15.00-15.49	0	0	0	0	0	0	0	0	0	1.3	0	0

Monthly Precipitation in inches	Percent Of Time (1859-1933)(75 years) in which the Indicated Amount of Monthly Precipitation has been equalled or exceeded.											
	Jan.	Feb	Mar	April	May	Jun.	Jul	Aug	Sept	Oct.	Nov.	Dec.
0.00-0.49	100.	100	100	100	100	100	100	100	100	100	100	100
0.50-0.99	100	100	98.7	100	96	96	100	100	97.3	100	100	100
1.00-1.49	100	97.3	98.7	100	93.3	93.3	98.7	100	90.7	97.3	93.3	100
1.50-1.99	97.3	90.7	93.3	94.7	88	86.7	93.3	92	86.7	84	92	98.7
2.00-2.49	89.3	81.3	86.7	82.7	81.3	77.3	81.3	84	76	77.3	81.3	92
2.50-2.99	76	74.7	84	73.3	74.7	65.3	69.3	78.7	58.7	70.7	73.3	78.7
3.00-3.49	64	62.7	70.7	62.7	65.3	57.3	54.7	73.3	46.7	57.3	60	65.3
3.50-3.99	49.3	53.3	61.3	41.3	54.7	41.3	48	66.7	42.7	48	48	54.7
4.00-4.49	40	44	50.7	32	45.3	29.3	42.7	61.3	29.3	40	46.7	34.7
4.50-4.99	32	30.7	42.7	20	36	21.3	30.7	50.7	26.7	30.7	33.3	26.7
5.00-5.49	26.7	26.7	33.3	14.7	27.7	17.3	25.3	32	20	24	28	22.7
5.50-5.99	21.3	16	28	12	17.3	10.7	18.7	32	16	18.7	22.7	14.7
6.00-6.49	8	12	21.3	6.7	16	10.7	13.3	25.3	12	14.7	16	93
6.50-6.99	6.7	8	18.7	6.7	9.3	5.3	9.3	20	9.3	12	10.7	5.3
7.00-7.49	4	8	13.3	5.3	5.3	4	6.7	14.7	8	9.3	6.7	5.3
7.50-7.99	1.3	5.3	12	2.7	2.7	2.7	6.7	10.7	8	9.3	1.3	4
8.00-8.49	1.3	1.3	6.7	2.7	0	2.7	6.7	8	4	6.7	1.3	1.3
8.50-8.99	1.3	1.3	6.7	1.3	0	1.3	6.7	4	4	5.3	0	1.3
9.00-9.49	1.3	1.3	4	1.3	0	1.3	6.7	1.3	2.7	4	0	1.3
9.50-9.99	0	0	0	1.3	0	1.3	6.7	1.3	2.7	2.7	0	1.3
10.00-1049	0	0	0	1.3	0	1.3	5.3	1.3	2.7	2.7	0	1.3
10.50-10.99	0	0	0	1.3	0	1.3	5.3	0	1.3	1.3	0	1.3
11.00-11.49	0	0	0	1.3	0	1.3	4	0	1.3	1.3	0	0
11.50-11.99	0	0	0	1.3	0	0	2.7	0	1.3	1.3	0	0
12.00-12.49	0	0	0	1.3	0	0	2.7	0	0	1.3	0	0
12.50-1299	0	0	0	0	0	0	2.7	0	0	1.3	0	0
13.00-13.49	0	0	0	0	0	0	2.7	0	0	1.3	0	0
13.50-1399	0	0	0	0	0	0	0	0	0	1.3	0	0
14.00-1449	0	0	0	0	0	0	0	0	0	1.3	0	0
14.50-14.99	0	0	0	0	0	0	0	0	0	1.3	0	0
15.00-15.49	0	0	0	0	0	0	0	0	0	1.3	0	0

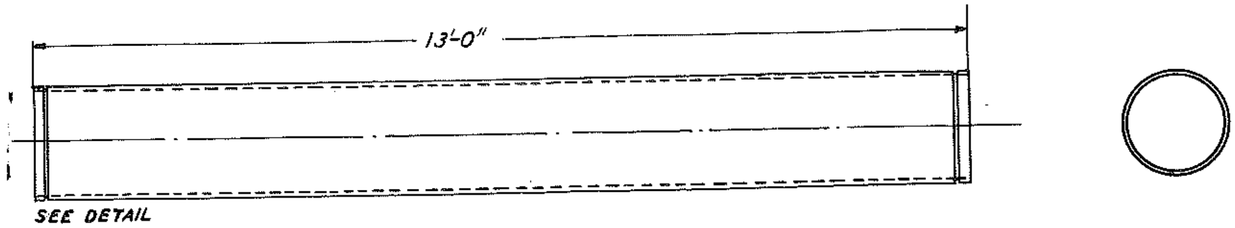
Annual and Monthly Precipitation (1859 - 1933 75 Years) arranged in their order of magnitude.

Annual	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
66.67	9.24	9.03	9.49	12.44	7.70	11.37	13.43	10.22	11.64	15.54	8.06	10.84
64.11	7.18	7.64	9.24	8.36	7.63	8.05	13.35	8.87	10.49	10.26	7.36	7.91
63.97	7.07	7.56	9.03	7.13	7.20	7.11	11.14	8.50	8.50	9.11	7.34	7.67
60.71	6.79	7.53	8.78	7.11	7.02	6.58	10.20	8.31	7.98	8.95	7.29	7.20
60.47	6.71	7.43	8.59	6.98	6.85	6.21	7.02	8.24	7.81	8.00	7.03	7.39
59.27	6.46	7.04	7.99	5.99	6.82	6.13	6.99	8.02	7.74	7.53	6.76	6.36
54.18	5.99	6.28	7.52	5.95	6.81	6.09	6.57	7.69	6.74	7.52	6.70	6.33
53.79	5.98	6.15	7.51	5.65	6.46	6.00	6.24	7.62	6.26	6.76	6.60	5.99
53.54	5.93	6.09	7.50	5.52	6.26	5.39	6.22	7.39	6.04	6.63	6.44	5.85
53.33	5.77	5.98	7.45	5.43	6.21	5.38	6.17	7.12	5.97	6.18	6.38	5.72
53.18	5.72	5.97	6.59	5.32	6.12	5.24	5.88	7.10	5.88	6.11	6.16	5.55
53.10	5.71	5.82	6.52	4.98	6.05	5.08	5.78	6.90	5.50	5.98	6.02	5.36
52.54	5.69	5.45	6.51	4.97	5.51	5.05	5.67	6.83	5.45	5.61	5.94	5.25
52.47	5.68	5.13	6.51	4.00	5.39	4.91	5.62	6.57	5.26	5.54	5.79	5.23
52.09	5.66	5.12	6.42	4.75	5.38	4.89	5.48	6.57	5.08	5.47	5.73	5.18
51.95	5.64	5.11	6.39	4.98	5.35	4.76	5.43	6.30	4.94	5.39	5.72	5.08
51.95	5.22	5.11	5.97	4.42	5.30	4.38	5.32	6.15	4.88	5.30	5.55	5.06
51.87	5.21	5.11	5.96	4.42	5.29	4.36	5.10	6.14	4.83	5.12	5.48	4.86
51.60	5.17	5.11	5.67	4.33	5.27	4.34	5.03	6.09	4.76	4.94	5.23	4.85
51.41	5.12	5.04	5.56	4.26	5.00	4.24	4.98	5.98	4.72	4.78	5.08	4.50
49.91	4.95	4.86	5.53	4.19	4.00	4.23	4.81	5.93	4.37	4.69	5.02	4.46
49.63	4.86	4.86	5.39	4.18	4.75	4.13	4.79	5.64	4.13	4.67	4.94	4.24
48.94	4.85	4.74	5.31	4.14	4.71	3.97	4.65	5.58	3.90	4.56	4.74	4.21
48.55	4.70	4.46	5.19	4.04	4.71	3.91	4.40	5.56	3.90	4.36	4.51	4.19
48.36	4.34	4.45	5.18	3.90	4.57	3.82	4.40	5.48	3.88	4.31	4.50	4.15
48.34	4.24	4.42	4.94	3.89	4.53	3.71	4.31	5.33	3.82	4.24	4.47	4.08
48.23	4.22	4.34	4.75	3.88	4.50	3.68	4.30	5.26	3.80	4.23	4.39	3.99
48.03	4.16	4.29	4.73	3.80	4.38	3.65	4.27	5.17	3.74	4.12	4.34	3.90
48.03	4.13	4.20	4.66	3.77	4.38	3.63	4.26	5.12	3.70	4.11	4.33	3.89
47.91	4.07	4.18	4.62	3.71	4.25	3.55	4.24	4.98	3.56	4.04	4.29	3.88
47.50	3.92	4.11	4.52	3.51	4.19	3.52	4.16	4.90	3.55	3.94	4.25	3.88
47.03	3.80	4.10	4.52	3.43	4.18	3.46	4.04	4.89	3.51	3.94	4.16	3.84
46.98	3.80	4.07	4.46	3.43	4.16	3.43	3.89	4.85	3.46	3.89	4.13	3.83
46.84	3.78	3.97	4.27	3.41	4.11	3.34	3.86	4.84	3.45	3.69	4.05	3.83
46.75	3.74	3.92	4.22	3.41	3.86	3.28	3.56	4.66	3.40	3.62	4.00	3.82
46.59	3.74	3.76	4.18	3.32	3.82	3.25	3.54	4.57	2.83	3.57	3.96	3.81
46.27	3.50	3.69	4.09	3.21	3.79	3.17	3.45	4.57	2.82	3.46	3.80	3.72

(Continued on Page)

Annual and Monthly Precipitation arranged in Order of Magnitude.

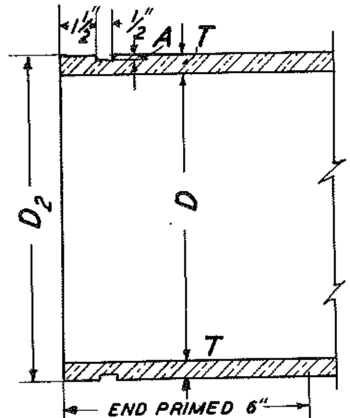
Annual	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
45.37	3.47	3.68	4.02	3.18	3.58	3.14	3.31	4.55	2.81	3.34	3.34	3.57
45.26	3.43	3.67	3.91	3.18	3.57	3.07	3.14	4.42	2.74	3.32	3.28	3.56
45.21	3.42	3.61	3.89	3.17	3.53	3.07	3.06	4.35	2.72	3.32	3.18	3.54
45.19	3.41	3.42	3.87	3.16	3.51	3.02	3.04	4.32	2.71	3.31	3.18	3.54
44.96	3.38	3.31	3.83	3.14	3.48	3.01	2.99	4.27	2.66	3.22	3.11	3.45
44.90	3.36	3.28	3.64	3.13	3.41	3.00	2.98	4.24	2.57	3.21	3.08	3.42
44.57	3.30	3.28	3.56	3.06	3.33	2.99	2.96	4.15	2.55	2.98	3.04	3.31
44.55	3.17	3.09	3.51	3.06	3.21	2.92	2.94	4.15	2.45	2.98	3.00	3.31
44.03	3.07	3.08	3.51	3.02	3.15	2.86	2.86	4.05	2.44	2.86	2.90	3.31
43.74	3.06	3.03	3.48	3.00	3.12	2.73	2.84	3.96	2.39	2.75	2.85	3.21
42.95	3.00	2.95	3.46	2.91	3.09	2.72	2.84	3.91	2.37	2.74	2.81	3.06
42.80	2.99	2.93	3.45	2.90	3.00	2.70	2.76	3.70	2.37	2.73	2.80	3.02
42.71	2.96	2.87	3.44	2.90	2.93	2.46	2.72	3.52	2.37	2.66	2.80	2.99
42.70	2.92	2.81	3.22	2.89	2.87	2.45	2.72	3.29	2.37	2.64	2.75	2.87
42.69	2.86	2.72	3.21	2.78	2.86	2.41	2.72	3.23	2.35	2.63	2.65	2.92
42.60	2.84	2.71	3.02	2.65	2.69	2.34	2.49	3.07	2.31	2.56	2.64	2.86
42.58	2.83	2.68	2.95	2.60	2.69	2.22	2.39	3.04	2.17	2.47	2.62	2.85
42.49	2.81	2.62	2.90	2.51	2.59	2.21	2.38	3.00	2.08	2.41	2.56	2.79
42.43	2.68	2.50	2.89	2.49	2.58	2.21	2.36	2.92	2.05	2.20	2.45	2.65
42.20	2.62	2.41	2.83	2.44	2.49	2.16	2.25	2.87	2.03	2.13	2.42	2.62
42.01	2.49	2.30	2.83	2.39	2.47	2.04	2.23	2.80	1.99	2.09	2.40	2.61
41.46	2.47	2.29	2.79	2.35	2.37	1.96	2.17	2.59	1.94	1.89	2.37	2.60
41.39	2.43	2.14	2.78	2.29	2.36	1.91	2.17	2.13	1.88	1.71	2.28	2.49
40.68	2.41	2.11	2.60	2.13	2.12	1.89	2.09	2.11	1.80	1.63	2.18	2.39
39.84	2.34	1.92	2.59	2.05	1.74	1.86	1.99	2.10	1.76	1.63	1.90	2.32
39.09	2.25	1.82	2.55	1.95	1.74	1.74	1.93	2.03	1.73	1.57	1.84	2.31
38.88	2.19	1.81	2.30	1.95	1.66	1.61	1.92	1.95	1.59	1.47	1.84	2.31
38.23	2.19	1.69	2.06	1.82	1.62	1.50	1.87	1.91	1.50	1.44	1.81	2.30
38.13	2.18	1.59	1.98	1.74	1.61	1.48	1.83	1.85	1.34	1.42	1.78	2.28
37.94	2.13	1.57	1.71	1.72	1.44	1.44	1.78	1.83	1.33	1.34	1.65	2.27
37.76	1.92	1.53	1.68	1.71	1.29	1.41	1.69	1.65	1.11	1.25	1.50	2.11
37.65	1.89	1.40	1.64	1.59	1.25	1.40	1.68	1.61	0.94	1.24	1.50	2.03
37.39	1.85	1.36	1.52	1.56	1.11	1.01	1.56	1.41	0.92	1.18	1.38	1.80
36.34	1.80	1.21	1.45	1.56	0.74	0.99	1.46	1.33	0.75	1.16	0.96	1.73
36.17	1.69	1.14	1.36	1.48	0.50	0.72	1.42	1.25	0.72	1.15	0.95	1.57
34.91	1.61	1.13	1.20	1.23	0.45	0.46	1.28	1.23	0.67	1.13	0.94	1.56
34.22	1.45	0.99	1.17	1.09	0.28	0.39	1.10	1.16	0.49	0.89	0.88	1.55
34.00	1.04	0.65	0.27	1.09	0.22	0.33	0.95	1.14	0.22	0.89	0.75	1.20



STANDARD LENGTH

RANDOM LENGTHS 8'-0", 9'-0", 10'-0", 11'-0", 12'-0" WILL BE SUPPLIED ON ANY ORDER UP TO 15% OF TOTAL.
RANDOM LENGTHS ON SPECIAL ORDER MAY BE OF LENGTH AS ABOVE; OR IF BELOW 8'-0" LONG; IN MULTIPLES OF 6", WITH A MINIMUM LENGTH OF 4'-0"

STENCIL MARKINGS:
SIZE & CLASS 2" HIGH: WORD SEWER OR CULVERT FOLLOWING:-
CODE DATE PRECEDED BY FACTORY LETTER W-WAUKEGAN, M-MANVILLE, J-WATSON-¾" HIGH.
PIPE 6" & LARGER TO CARRY SERIAL NUMBER: 1" HIGH.
HYDROSTATIC TEST MARKINGS-¾" HIGH.
CLASS I SEWER TESTED TO 100 LBS.
" II " " " 150 "
" III CULVERT " " 200 "
" IV " " " 250 "
THE WORD BLOCK: CIRCUMFERENTIAL DIRECTION: 1" HIGH-
4'-0" TO 6'-0", 9" FROM ONE END ONLY.
6'-6" " 8'-0", 12" " EACH "
9'-0" 22½ " " "
10'-0" 25" " " "
11'-0", 27½" FROM EACH END.
12'-0", 30" " " "
13'-0", 32½" " " "



DETAIL OF END GROOVING

FOR JOINT ASSEMBLY SEE DWG. Nº TP 343

TABLE OF DIMENSIONS IN INCHES										ULTIMATE STRENGTH LBS. PER LIN. FT.			
PIPE SIZE		CLASS I		CLASS II		CLASS III		CLASS IV					
D	A	T	D_2	T	D_2	T	D_2	T	D_2	CLASS I	CLASS II	CLASS III	CLASS IV
4	.125	.39	4.78	—	—	—	—	—	—	4125	—	—	—
6	.125	.42	6.84	—	—	—	—	—	—	2880	—	—	—
8	.125	.48	8.96	—	—	—	—	—	—	3100	—	—	—
10	.125	.50	11.00	.56	11.12	.65	11.30	-	—	2580	3690	4920	—
12	.125	.54	13.08	.64	13.28	.74	13.48	—	—	2370	3850	5100	—
14	.125	.58	15.16	.73	15.46	.84	15.68	—	—	2200	3920	5150	—
16	.125	.62	17.24	.82	17.64	.94	17.88	—	—	2120	4050	5280	—
18	.180	.65	19.30	.90	19.80	1.03	20.06	1.12	20.24	2030	4140	5360	6340
20	.180	.69	21.38	.94	21.88	1.13	22.26	1.25	22.50	2290	4280	5850	7100
24	.180	.75	25.50	1.06	26.12	1.31	26.62	1.45	26.90	2340	4550	7050	8600
30	.180	.96	31.92	1.24	32.48	1.64	33.28	1.85	33.70	2980	5000	8180	10450
36	.180	1.15	38.30	1.41	38.82	1.93	39.86	2.18	40.36	3500	5400	9700	12300

TOLERENCES:- STANDARD & RANDOM LENGTH ± 1"

D_2 - 4" TO 10" +.12"-.08"
12" TO 20" +.15"-.08"
24" TO 36" +.20"-.10"

OUT OF ROUND: 4" TO 10" .125"
12" TO 20" .190"
24" TO 36" .250"

GROOVE: DISTANCE FROM END ±.125"
WIDTH - ±.063
DEPTH - 4" TO 16" +.03"-.09"
18" TO 24" +.04"-.14"
30" TO 36" +.10"-.14"

D_2 & OUT OF ROUND TOLERANCES NOT CUMULATIVE-

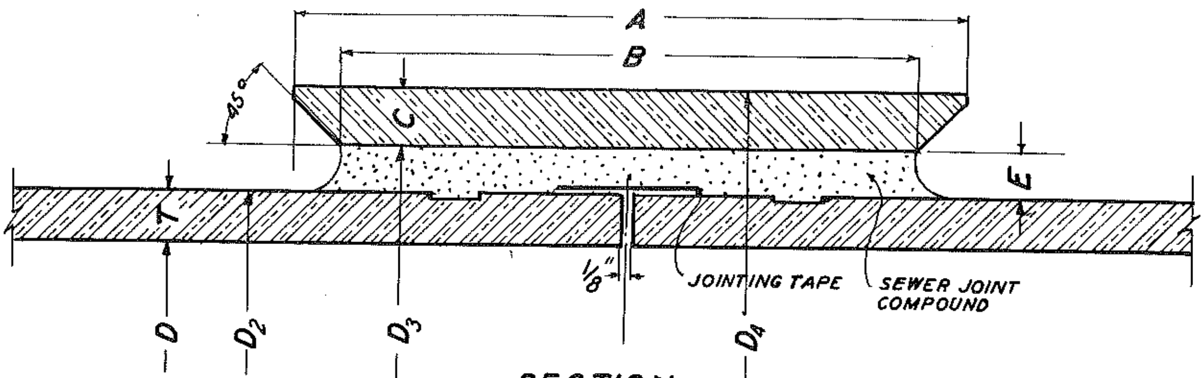
JOHNS-MANVILLE SALES CORP.
TRANSITE PIPE DEPARTMENT

TRANSITE PIPE

NO SCALE — DATE 9-6-39 — REV. 10-24-39

TRANSITE SEWER & CULVERT PIPE
CLASSES I, II, III, IV

DRAWING Nº TP 342



SECTION
SLEEVE SHOWN ASSEMBLED ON TRANSITE
SEWER & CULVERT PIPE

FOR GROOVED END OF PIPE SEE DWG. N° TP 342

JOINTING TAPE & COMPOUND SUPPLIED WITH PIPE

STENCIL MARKING
SIZE & CLASS CIRCUMFERENTIAL
4" TO 10" PIPE 3/4" HIGH
12"-36" " 2" "

PIPE SIZE	CLASS I SEWER PIPE								CLASS II SEWER PIPE							
D	T	D_2	D_3	D_4	A	B	C	E	T	D_2	D_3	D_4	A	B	C	E
4	.39	4.78	5.55	6.65	7.0	6	.55	.38	–	–	–	–	–	–	–	–
6	.42	6.84	7.60	8.70	7.0	6	.55	.38	–	–	–	–	–	–	–	–
8	.48	8.96	9.72	10.90	7.0	6	.59	.38	–	–	–	–	–	–	–	–
10	.50	11.00	12.00	13.20	7.0	6	.60	.50	.56	11.12	12.00	13.34	7.0	6	.67	.44
12	.54	13.08	14.00	15.25	7.0	6	.62	.46	.64	13.28	14.18	15.70	7.0	6	.76	.45
14	.58	15.16	16.00	17.30	8.0	7	.65	.42	.73	15.46	16.36	18.06	8.0	7	.85	.45
16	.62	17.24	18.10	19.50	8.0	7	.70	.43	.82	17.64	18.54	20.44	8.0	7	.95	.45
18	.65	19.30	20.20	21.64	8.0	7	.72	.45	.90	19.80	20.76	22.82	8.0	7	1.03	.48
20	.69	21.38	22.30	23.80	9.0	8	.75	.46	.94	21.88	22.90	25.00	9.0	8	1.05	.51
24	.75	25.50	26.40	28.10	9.0	8	.85	.45	1.06	26.12	27.10	29.44	9.0	8	1.17	.49
30	.96	31.92	32.85	34.90	10.5	9	1.03	.46	1.24	32.48	33.46	36.26	10.5	9	1.40	.49
36	1.15	38.30	39.50	42.00	10.5	9	1.25	.60	1.41	38.82	39.80	42.94	10.5	9	1.57	.49
	CLASS III CULVERT PIPE								CLASS IV CULVERT PIPE							
10	.65	11.30	12.20	13.80	7.0	6	.80	.45	–	–	–	–	–	–	–	–
12	.74	13.48	14.40	16.30	7.0	6	.95	.46	–	–	–	–	–	–	–	–
14	.84	15.65	16.60	18.70	8.0	7	1.05	.46	–	–	–	–	–	–	–	–
16	.94	17.88	19.00	21.30	8.0	7	1.15	.56	–	–	–	–	–	–	–	–
18	1.03	20.06	21.00	23.50	8.0	7	1.25	.47	1.12	20.24	21.20	23.94	8.0	7	1.37	.48
20	1.13	22.26	23.20	25.92	9.0	8	1.36	.47	1.25	22.50	23.46	26.50	9.0	8	1.52	.48
24	1.31	26.62	27.60	30.72	9.0	8	1.56	.49	1.45	26.90	27.90	31.38	9.0	8	1.74	.50
30	1.64	33.28	34.28	38.12	10.5	9	1.92	.50	1.85	33.70	34.70	39.08	10.5	9	2.19	.50
36	1.93	39.86	40.86	45.34	10.5	9	2.24	.50	2.18	40.36	41.36	46.46	10.5	9	2.55	.50

TOLERANCES:-
LENGTH 'A'- 4" TO 12" PIPE ±.25"; 14" TO 20" " ±.375"; 24" TO 36" " ±.500"
DIAMETER D_3 4" TO 10" PIPE -.05" +.08"; 12" TO 20" " -.05" +.10"; 24" TO 36" " -.05" +.12"
OUT OF ROUND 4" TO 10" PIPE .125" MAX.; 12"-20" " .190 "; 24"-36" " .250 "
THICKNESS OF COUPLING -.10"
BEVEL ±5°

JOHNS-MANVILLE SALES CORP.
TRANSITE PIPE DEPARTMENT

TRANSITE COUPLING
NO SCALE
DATE 9-6-39
REV. 10-24-39

SLEEVE COUPLING FOR TRANSITE SEWER AND CULVERT PIPE.

DRAWING N° TP 343

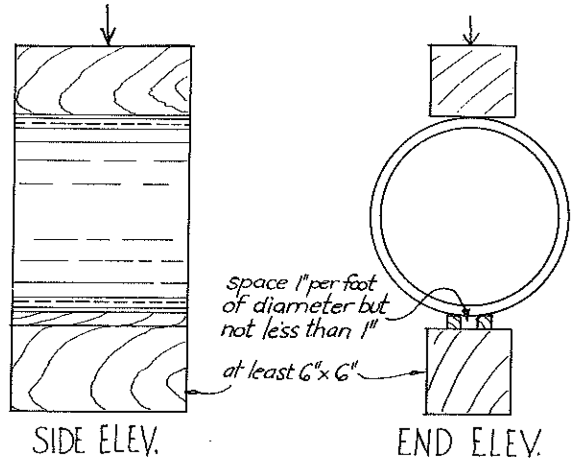
APPENDIX V

Relation Between 3-Edge Bearing Test and Actual Supporting Strength of Pipe

The following relations between laboratory test strengths, as indicated by the 3-edge bearing test, and the actual supporting strengths of equivalent pipe when in the trench have been worked out during several years of experimentation by the Iowa Engineering Experiment Station, partly in cooperation with the United States Bureau of Public Roads:

For "impermissible" bedding	=	1.12 Seb
For "ordinary" bedding	=	1.50 Seb
For "first class" bedding	=	1.87 Seb
For "concrete cradle" bedding	=	2.25 to 3.37 Seb

Where Seb = 3-edge bearing laboratory strength in lb. per ft. of pipe.



The 3-edge bearing test

"Impermissible" bedding is that method of bedding pipe in which materially insufficient care is exercised to shape the foundation surface to fit the lower part of the pipe exterior and to fill all spaces under and around the pipe with granular materials at least partially compacted.

"Ordinary" bedding is that method of bedding pipe completely buried in ditches in which the pipe is bedded with "ordinary care", in an earth foundation shaped to fit the lower part of the pipe exterior with reasonable closeness for a width of at least 50 percent of the pipe breadth; and in which the remainder of the pipe is surrounded to a height of at least 0.5 ft. above its top by granular materials, shovel-placed and shovel-tamped to fill completely all spaces under and adjacent to the pipe; all under the general direction of a competent engineer.

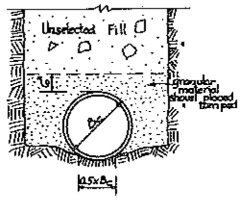
When Transite Sewer Pipe is laid on two wood blocks, one at each blocking point (one-fifth of the length of the pipe from each end), and the spaces under and around the pipe are refilled with granular materials well tamped in place, the bedding may be considered "ordinary" bedding.

"First class" bedding is that method of bedding pipe completely buried in ditches in which the pipe is bedded carefully on fine granular materials in an earth foundation carefully shaped to fit the lower part of the pipe exterior for a width of at least 60 percent of the pipe breadth; and in which the remainder of the pipe is entirely surrounded to a height of at least 1.0 ft. above its top by granular materials which have been carefully placed by hand to completely fill all spaces under and adjacent to the pipe, and thoroughly tamped on each side and under the pipe so far as practicable, in layers not exceeding 0.5 ft. in thickness; all under the direction of a competent engineer, represented by a competent inspector constantly present during the operation.

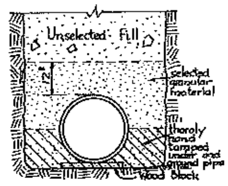
"Concrete cradle" bedding is that method of bedding pipe in which the lower part of the pipe exterior is bedded in plain or reinforced concrete of suitable thickness under the lowest part of the pipe exterior and extending upward on each side of the pipe for a greater or less proportion of its height.

(Over)

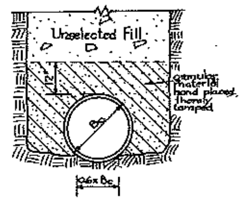
Impermissible Bedding



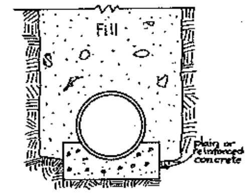
Ordinary Bedding



Wood Block Bedding



First Class Bedding



Concrete-cradle Bedding

Table 1 gives the laboratory test strength of Transite Sewer Pipe as determined by the 3-edge bearing test made in accordance with the procedure set forth by the American Society of Testing Materials.

Table 2 gives the actual supporting strength of Transite Sewer Pipe when bedded by each of the four methods of bedding commonly employed. The use of wood blocks is equivalent to "ordinary" bedding.

Table 3 gives the trench loads for various depths and widths of trench in various types of soil.

Table 1: Average Strength of Transite Sewer Pipe
A.S.T.M. 3-edge bearing test

Pipe size, inches	Lb. per Linear Foot	
	Class 1	Class 2
4	3490	----
6	2540	----
8	2790	----
10	2360	3690
12	2180	3850
14	2040	3920
16	1965	4050
18	2000	4140
20	2150	4280
24	2400	4550
30	2790	5000
36	3280	5400

Table 2: Actual Supporting Strength of Transite Sewer Pipe
with Various Types of Bedding
(lb. per linear feet of pipe)

Pipe size, inches	Impermissible		Ordinary		First Class		Concrete Cradle	
	Class 1	Class 2	Class 1	Class 2	Class 1	Class 2	Class 1	Class 2
4	3910	----	5235	----	6525	----	9810	----
6	2845	----	3810	----	4755	----	7150	----
8	3125	----	4185	----	5220	----	7850	----
10	2640	4140	3540	5540	4420	6900	6640	10380
12	2440	4305	3285	5770	4080	7200	6130	10820
14	2285	4395	3060	5880	3820	7340	5735	11000
16	2200	4545	2950	6075	3680	7575	5550	11390
18	2240	4630	3000	6200	3740	7740	5620	11610
20	2410	4790	3225	6420	4025	8000	6041	12030
24	2690	5095	3600	6825	4490	8505	6745	12780
30	3125	5600	4185	7500	5220	9350	7850	14050
36	3685	6050	4920	8100	6135	10100	9225	15100

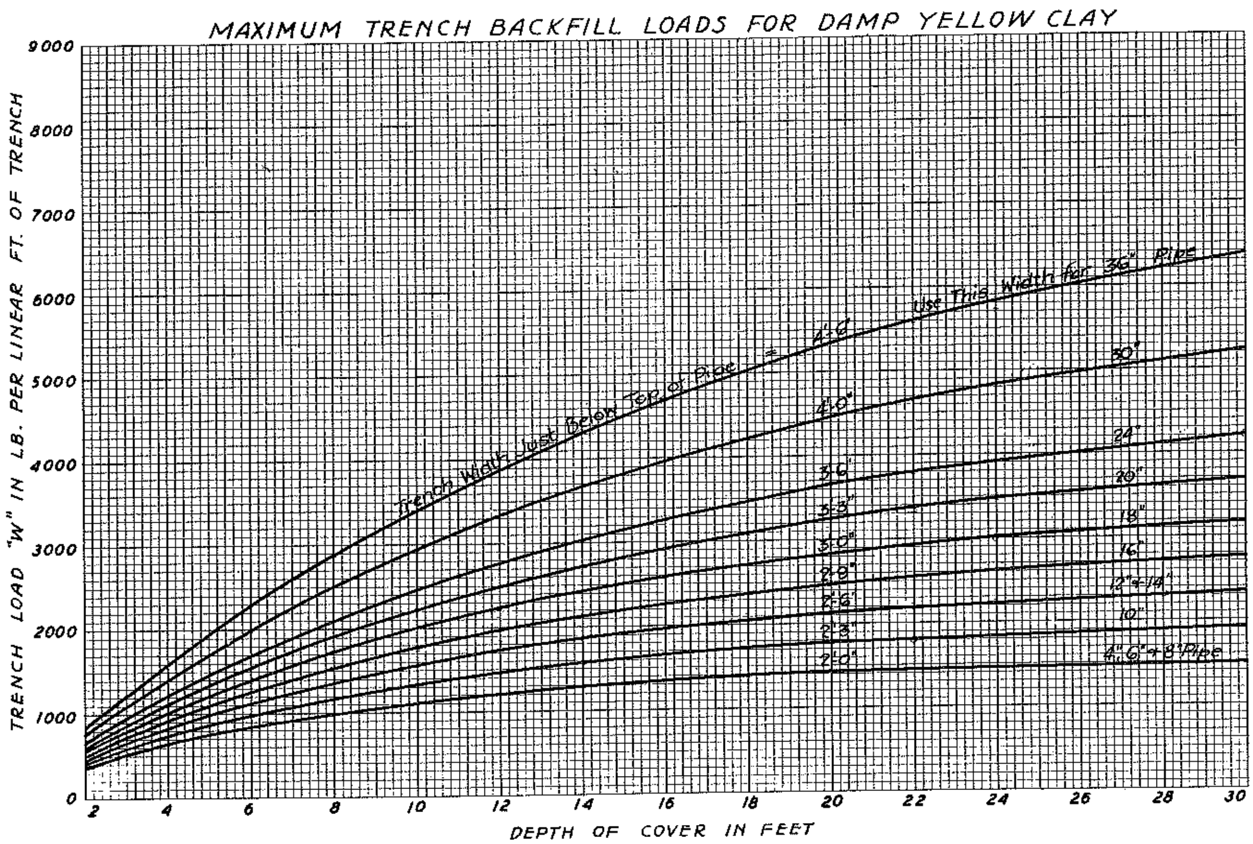
Table 3: Approximate Maximum Loads Imposed on Pipe in Trenches by Common Filling Materials
Lb. per Lin. Ft. of Pipe
(Marston and Anderson)

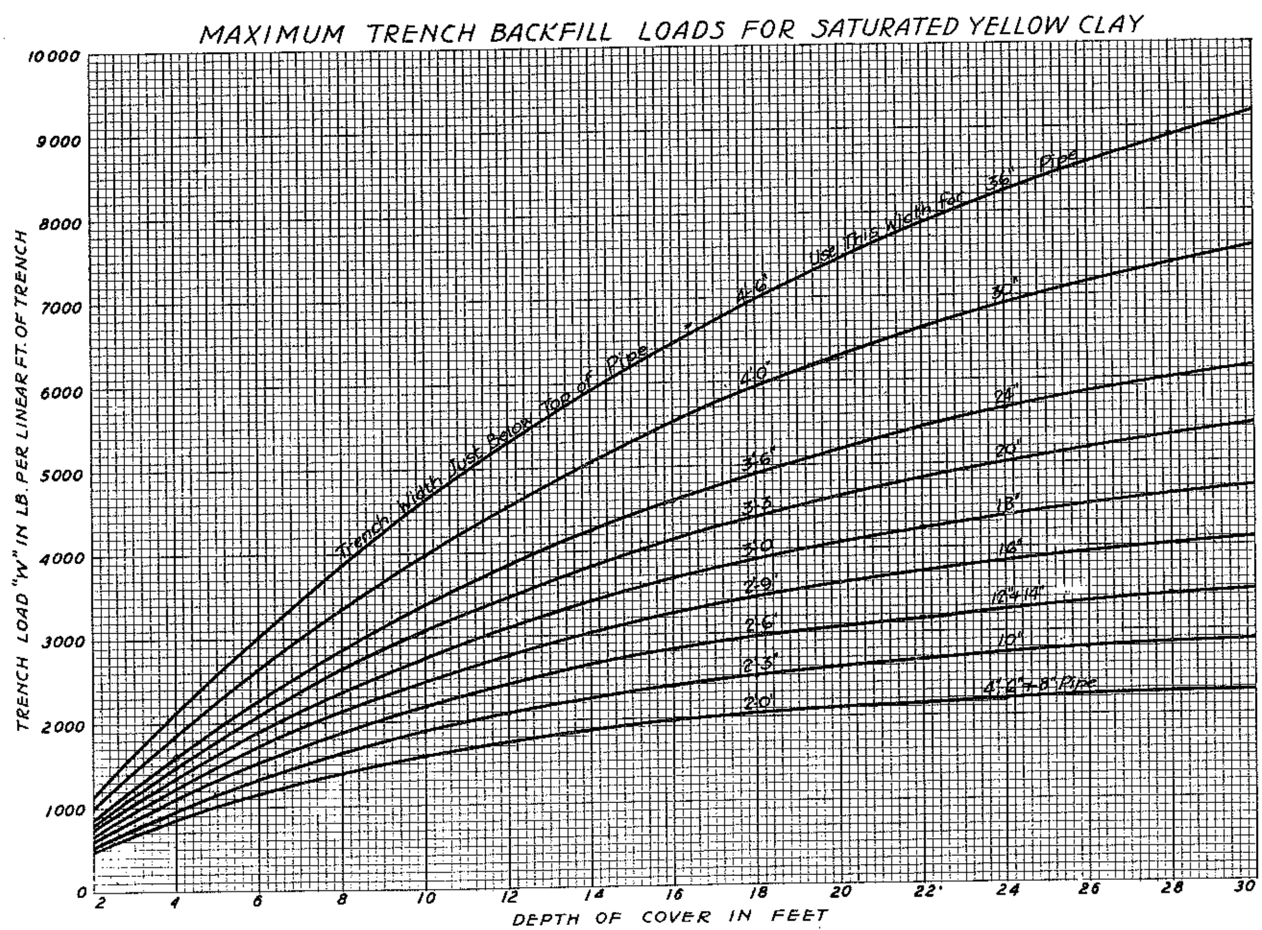
Depth of fill above pipe, ft.	Width of trench at top of pipe, ft.									
	1	2	3	4	5	1	2	3	4	5
	Dry Sand (100 lb. per cu.ft.)					*Saturated Sand (120 lb. per cu.ft.)				
2	150	340	550	740	930	180	410	650	890	1110
4	220	590	970	1360	1750	270	710	1170	1640	2100
6	260	760	1320	1890	2480	310	910	1590	2270	2870
8	280	890	1590	2350	3100	340	1070	1910	2820	3720
10	290	980	1820	2720	3650	350	1180	2180	3260	4380
12	300	1040	2000	3050	4150	360	1250	2400	3650	4980
14	300	1090	2140	3320	4580	360	1310	2570	3990	5490
16	300	1130	2260	3550	4950	360	1350	2710	4260	5940
18	300	1150	2350	3740	5280	360	1380	2820	4490	6330
20	300	1170	2420	3920	5550	360	1400	2910	4700	6660
22	300	1180	2480	4060	5800	360	1420	2980	4880	6960
24	300	1190	2540	4180	6030	360	1430	3050	5010	7230
26	300	1200	2570	4290	6210	360	1440	3090	5150	7460
28	300	1200	2600	4370	6390	360	1440	3120	5240	7670
30	300	1200	2630	4450	6530	360	1440	3150	5340	7830
	Partly Compacted Damp Yellow Clay (100 lb. per cu. ft.)					*Saturated Yellow Clay (130 lb. per cu.ft.)				
2	160	350	550	750	930	210	470	730	1000	1240
4	250	620	1010	1400	1800	340	840	1330	1870	2370
6	300	830	1400	1990	2580	430	1140	1900	2630	3410
8	330	990	1720	2500	3250	490	1380	2360	3360	4400
10	350	1110	2000	2920	3880	520	1570	2760	3980	5270
12	360	1200	2220	3320	4450	540	1730	3100	4560	6050
14	370	1280	2410	3650	4950	560	1850	3410	5050	6760
16	370	1330	2570	3950	5400	570	1940	3660	5510	7440
18	380	1380	2710	4210	5810	570	2020	3880	5930	8060
20	380	1410	2830	4450	6180	580	2090	4070	6280	8610
22	380	1430	2920	4640	6500	580	2140	4240	6610	9130
24	380	1450	3000	4820	6800	580	2180	4380	6910	9590
26	380	1470	3060	4980	7080	580	2210	4500	7160	10010
28	330	1480	3120	5100	7310	580	2240	4610	7380	10430
30	380	1490	3170	5230	7530	580	2260	4700	7590	10780

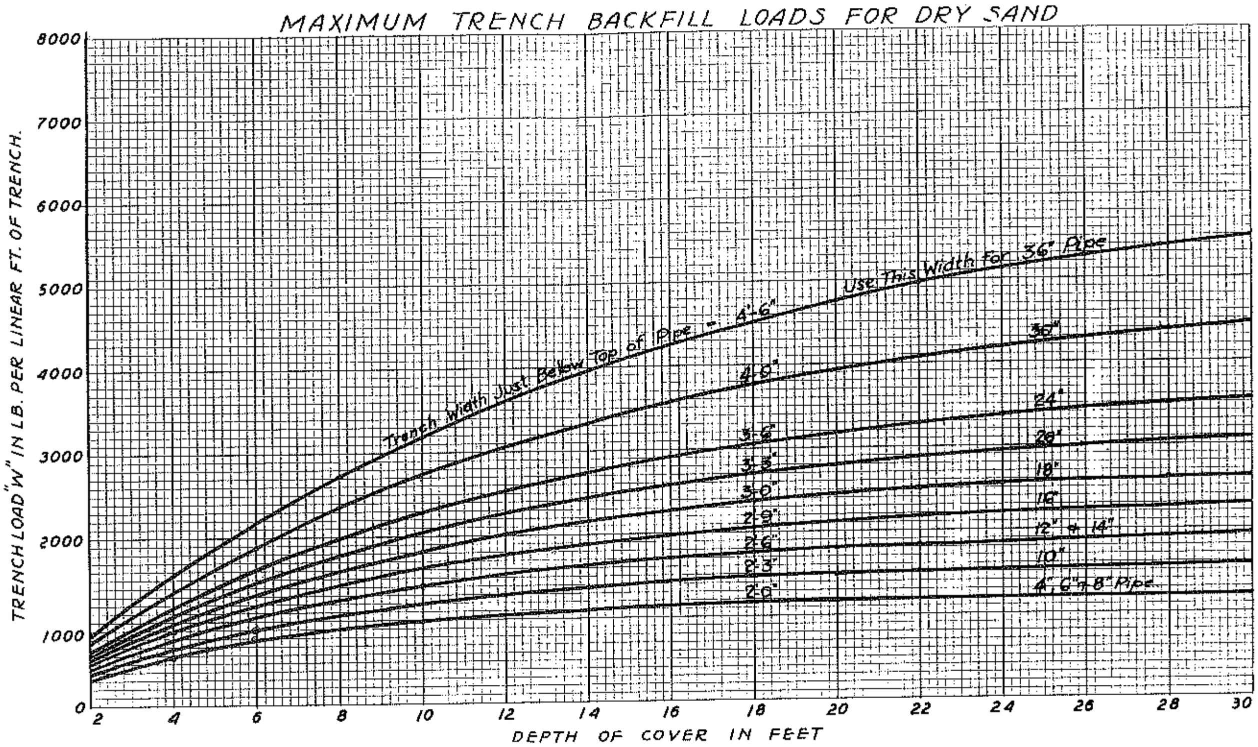
*These two sub-tables, "Saturated Sand" and "Saturated Yellow Clay", contain the most important figures for practical use.

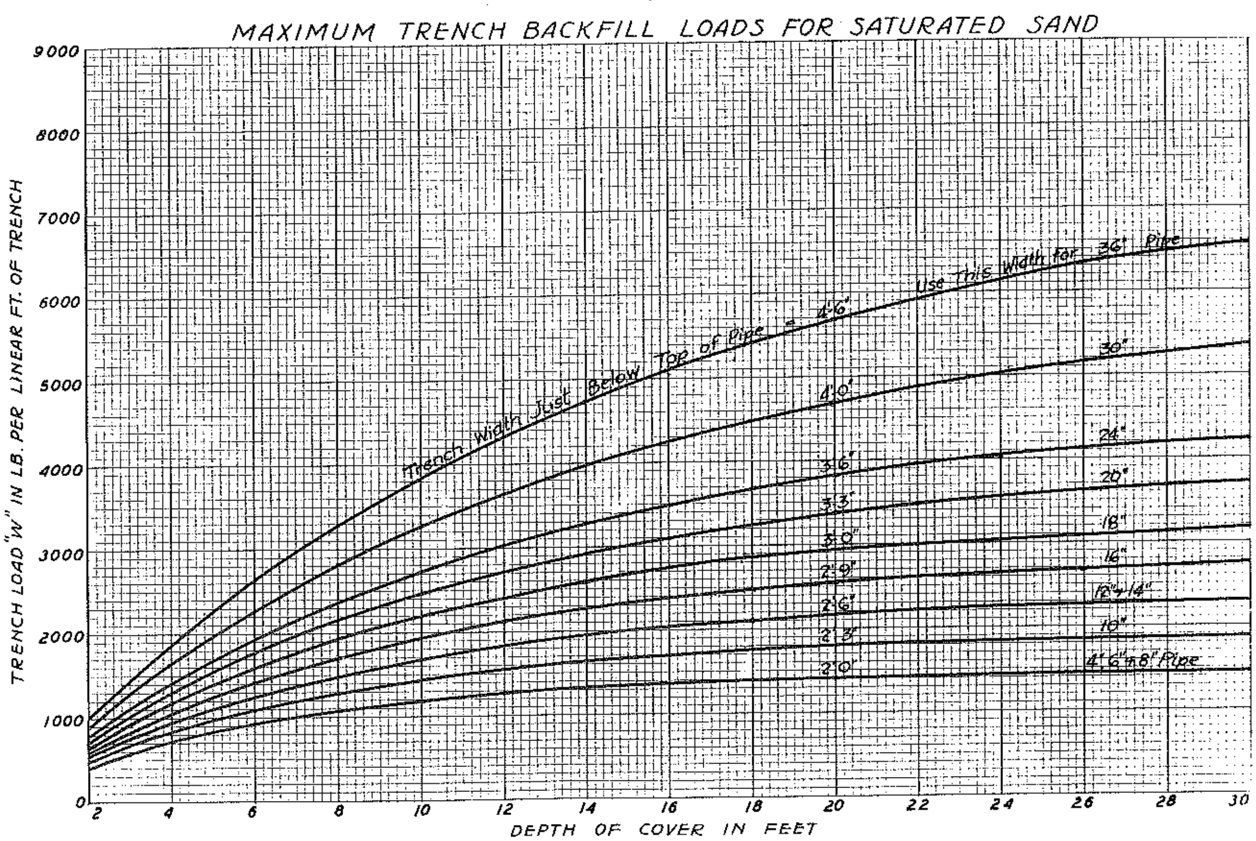
On the following two pages there appear graphs based upon the maximum trench load figures shown in Table 3, above. The curves indicate the maximum loads on each size of pipe when the pipe is laid in a trench of the recommended width, which is shown over each curve. These curves, in conjunction with the figures in Table 2, indicate the type of bedding required.

Appendix V - continued






MAXIMUM TRENCH BACKFILL LOADS FOR DRY SAND
TRENCH LOAD "W" IN LB. PER LINEAR FT. OF TRENCH.
DEPTH OF COVER IN FEET
Trench Width Just Below Top of Pipe = 4'6" Use This Width for 36" Pipe
4'0"
3'6"
3'3"
3'0"
2'9"
2'6"
2'3"
2'0"
30"
24"
20"
18"
16"
12" + 14"
10"
4", 6" + 8" Pipe


MAXIMUM TRENCH BACKFILL LOADS FOR SATURATED SAND
TRENCH LOAD "W" IN LB. PER LINEAR FT. OF TRENCH
DEPTH OF COVER IN FEET
Trench Width Just Below Top of Pipe = 4'6" Use This Width for 36" Pipe
4'0"
3'6"
3'3"
3'0"
2'9"
2'6"
2'3"
2'0"
30"
24"
20"
18"
16"
12" + 14"
10"
4", 6" + 8" Pipe

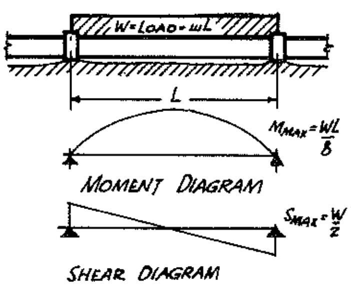
APPENDIX VI

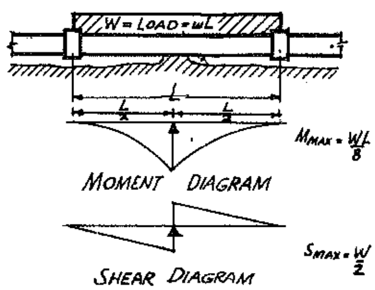
Using Wood Blocks in Bedding Transite Sewer Pipe

Bedding of Transite Sewer Pipe on wood blocks is recommended as a means to eliminate much of the uncertainty of trying to shape the bottom of the trench to conform to the barrel of the pipe along its full length. The use of templates and rigid inspection are essential to secure a properly shaped trench bottom. If templates and rigid inspection are not used, the pipe may contact the bottom of the trench only at the ends of the pipe or at the center of the pipe, with resultant failure in flexure or crushing.

The following diagrams illustrate the relative loading of pipe supported at the ends, at the center and at the predetermined blocking points. It should be noted that when the pipe is supported at the blocking points, it will carry a load of 5.8 times that which it will carry when supported at either ends or center.

Bedding the pipe on wood blocks which have been placed under the marked blocking points, together with well tamped backfill under and up to the horizontal diameter of the pipe, will assure development of sufficient supporting strength in flexure and crushing to be equivalent to "ordinary" bedding, described in Appendix V.





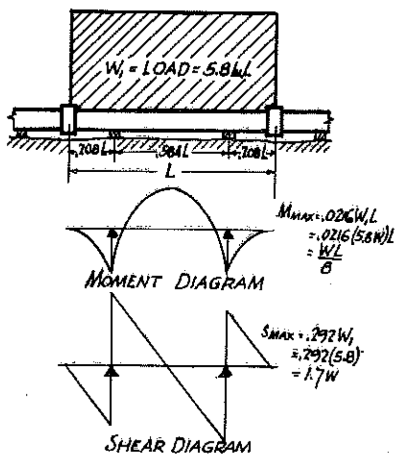


Table 1

Sizes of Wood Blocks

Pipe size, inches	Size of Blocks,* inches	Board ft. per 1000 ft. of pipe**
4 to 6	2 x 4 x 10	86
8 to 12	2 x 6 x 12	154
14 & 16	2 x 8 x 16	274
18	$2\frac{1}{2}$ x 8 x 16	342
20 & 24	$2\frac{1}{2}$ x 10 x 16	481
30 †	3 x 12 x 24	924
36 †	4 x 12 x 24	1232

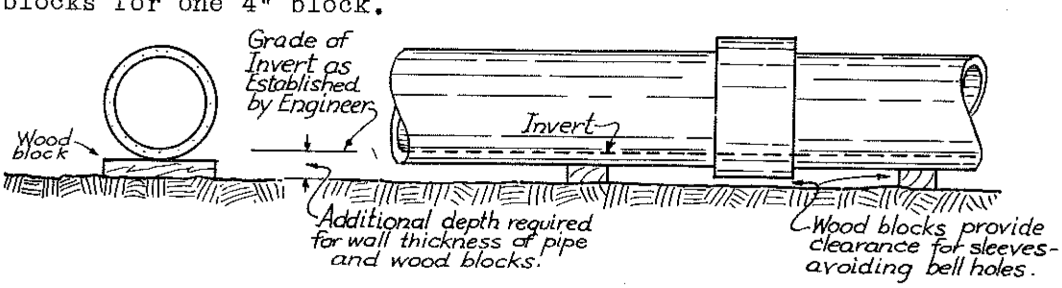
*Applies to undressed lumber.
**Applies only when trench bottom is dug to proper grade.
† Instead of 3" or 4" blocks, combinations of thicknesses may be used; as two 2" blocks for one 4" block.

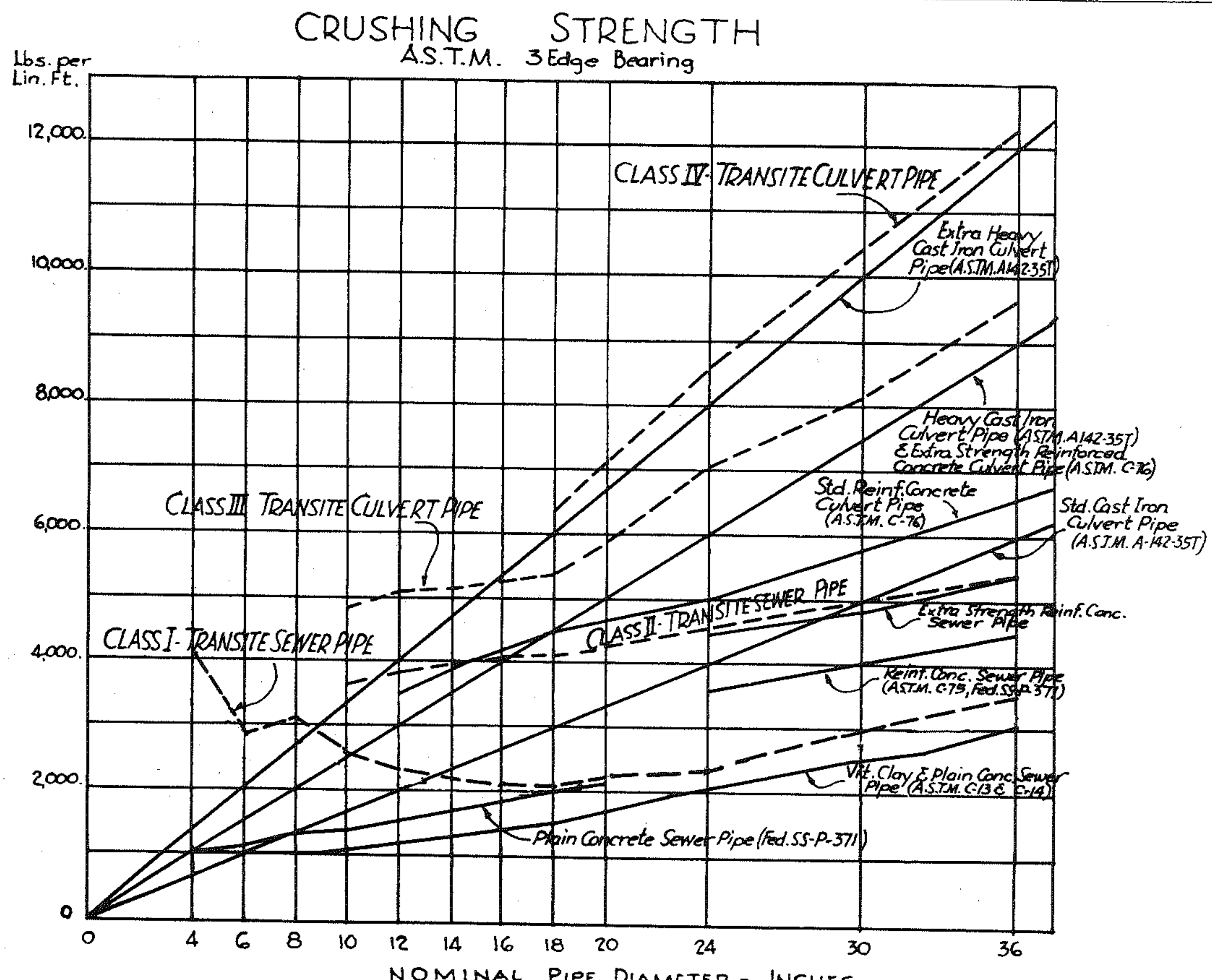
Table 2

Depth of Trench Bottom Below Invert

Pipe size, inches	Depth in inches* Class 1	Class 2
4 to 10	$2\frac{3}{4}$	---
12 to 16	3	---
18	$3\frac{1}{2}$	---
20	$3\frac{1}{2}$	$3\frac{3}{4}$
24	$3\frac{1}{2}$	4
30	$4\frac{1}{4}$	$4\frac{1}{2}$
36	$5\frac{1}{2}$	$5\frac{3}{4}$

*An allowance of approximately $\frac{1}{4}$" has been made to provide for the thickness of shingles to be used in bringing the pipe to the exact grade.





- TRANSITE SEWER AND CULVERT PIPE -

ALIGNMENT DIAGRAM

for the solution of the formula

$$Q = \frac{D}{5280} \times \frac{R}{7.5 \times 86{,}400}$$

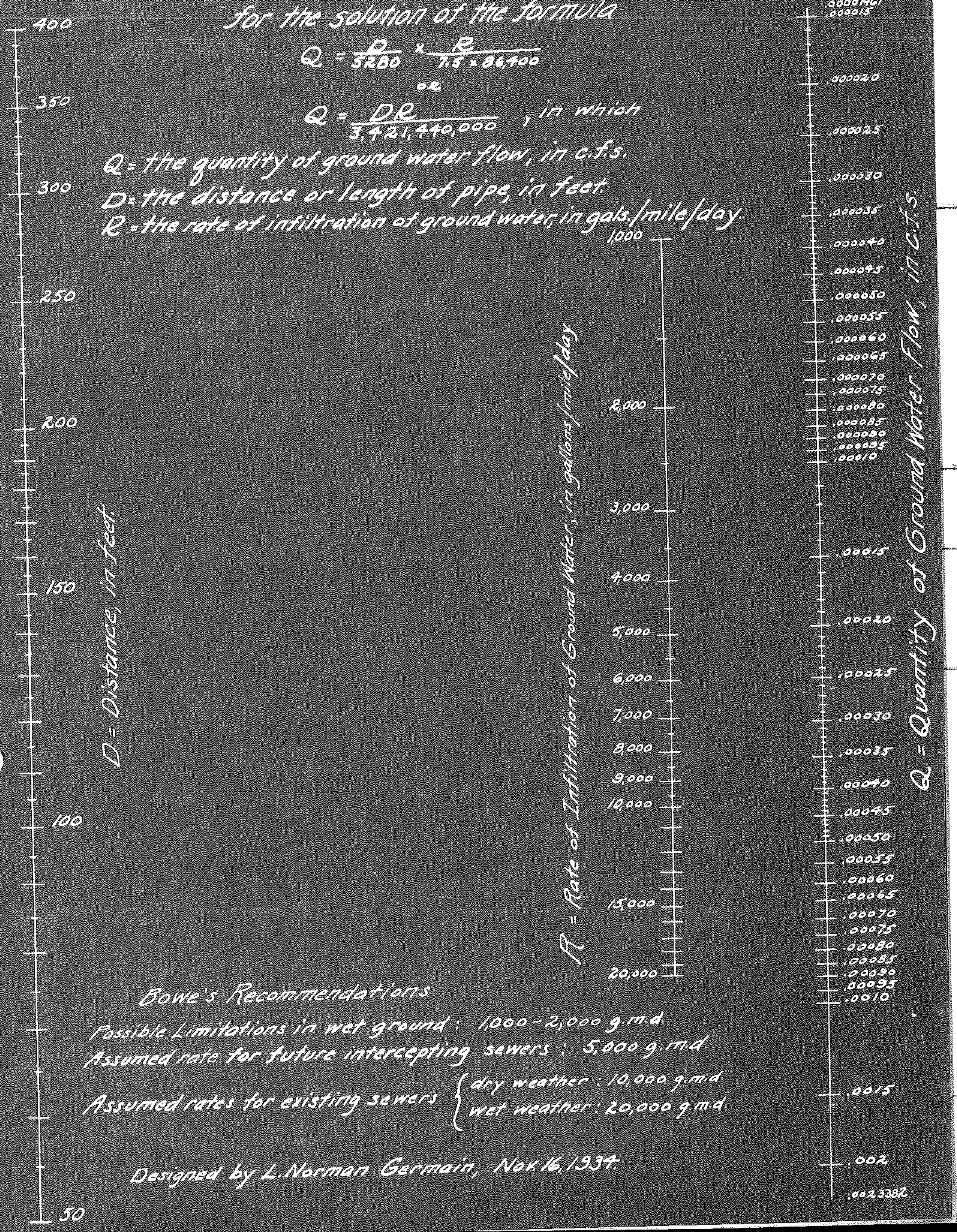
or

$$Q = \frac{DR}{3{,}421{,}440{,}000}$$, in which

Q = the quantity of ground water flow, in c.f.s.

D = the distance or length of pipe, in feet.

R = the rate of infiltration of ground water, in gals./mile/day.



Bowe's Recommendations

Possible Limitations in wet ground: 1,000 - 2,000 g.m.d.

Assumed rate for future intercepting sewers: 5,000 g.m.d.

Assumed rates for existing sewers { dry weather: 10,000 g.m.d. / wet weather: 20,000 g.m.d.

Designed by L. Norman Germain, Nov. 16, 1934.