CONNECTICUT RIVER FLOOD CONTROL

ANALYSIS OF DESIGN

MEADOW HILL PUMPING STATION

EAST HARTFORD, CONNECTICUT

CORPS OF ENGINEERS, UNITED STATES ARMY

UNITED STATES ENGINEER OFFICE PROVIDENCE, RHODE ISLAND

ANALYSIS OF DESIGN

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I. INTRODUCTION

I. INTRODUCTION

A. Authorization. - The Meadow Hill Pumping Station is a part of the local flood protection works for the Town of East Hartford. The East Hartford dike project is a part of the Connecticut River flood control plan included in the "Report of Survey and Comprehensive Plan for Flood Control in the Connecticut River Valley," March 20, 1937, approved by the Chief of Engineers, November 29, 1937 and published as House Document No. 455, 75th Congress, 2nd session. The project is authorized under the Flood Control Act approved June 28, 1938. Certain modifications in the type of construction and the alignment of the works were recommended by the Chief of Engineers in House Document No. 653, 76th Congress, 3rd session and authorized in the Act entitled "An Act to provide for the completion of certain local protection works at East Hartford, Connecticut," (Public No. 859, 76th Congress, 3rd session), approved October 15, 1940.

B. Necessity for the station. - The completion of the dike would result in preventing the natural drainage of a large portion of the area within the dike from flowing into the Connecticut River. Approximately 980 acres of developed and undeveloped land are drained by a combination of storm water sewers and open ditches, all discharging into the Swale, which, in turn, flows into the Hockanum River and thence into the Connecticut River. To prevent the accumulation of water behind the dike and resultant flooding of the Town of East Hartford, a pumping station is to be constructed which will discharge the accumulated water and sanitary sewage into the river at river stages which are too high for gravity flow. The water from natural drainage will be accumulated in a small storage pond which will smooth out peak run-off flows and reduce the

pumping capacity required. During periods of normal river stage this pond will empty into the river through a gravity flow conduit extending from the pond through the dike, where the conduit will terminate in an open channel to the river. Pumping will be necessary when the river stage exceeds Elevation 10.0 m.s.l. datum. The pond will have a capacity of 40 acre-feet between Elevation 4.0 and 10.0 m.s.l. datum exclusive of natural storage in the Swale, and will serve to store all peak discharges in excess of the pumping or gravity-flow capacity of the conduit.

C. Consultation with the Town of East Hartford. - Preliminary to and during the actual design of the pumping station, consultations were held with officials representing the Town of East Hartford. These latter include members of the Town Council, the Town Engineer, the head of the Sewer Department, and others. The pumping station design, as finally developed, meets with the approval, in its essentials, of the officials of the Town of East Hartford.

D. Short description of the station. - The pumping station which will house the pumps and other equipment will consist of a reinforced concrete sub-structure and a one-story superstructure, of structural steel and brick. A reinforced concrete entrance chamber for sanitary sewage, equipped with racks, will be provided. The necessary outfall under the dike will consist of an intake structure, a 6' x 8' conduit, and an outlet structure containing a sluice gate for emergency use. The superstructure will have glass block panels to serve as windows. The concrete roof slab will be covered with a cinder concrete fill, pitched to drain, with a built-up type roof composed of four-ply asphalt and gravel. Four 36-inch propeller pumps and one 16-inch Volute pump will be installed. The engine

room will contain the gasoline engines and right angle gear units for the four 36-inch pumps and an electrically driven motor for the 16-inch pump. An overhead crane will be installed for handling the equipment. There will be a structural steel foot bridge constructed to provide access to the outlet structure from the top of the dike.

II. HYDROLOGY

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A. Drainage area. - The drainage area of 980 acres, as shown on Plate 1, consists of 530 acres of developed commercial and residential area and 450 acres of undeveloped meadow land. The topography of the area is such as to produce a very definite line of demarcation between the developed and the undeveloped sections. The most important section of the town of East Hartford is located on the flat terrace, which has a ground elevation above 30, m.s.l. datum. The low-lying undeveloped area has an average ground elevation of from 12 to 15 feet above mean sea level, datum.

1. Present conditions. - The low area is subject to frequent flooding, and as a result has remained comparatively undeveloped. Open ditches in conjunction with a swale constitute the only drainage afforded for this area. The developed area is served by a separate system of storm drains running normal to Prospect Street and discharging directly into the swale. Reference is made to Plate 1 for limits of the drainage area. An intercepting sewer following along Prospect Street collects all sanitary sewage from the area, and discharges into the Hockanum River at the lower end of the swale.

2. Possible future conditions. - It is probable that the 450 acres of undeveloped land will be improved and made useful after full protection is effected. The flow of the swale may be enclosed in a conduit with drains constructed to provide more effective drainage for the area; however, local authorities, when consulted on the

question of future development, expressed the belief that the area will become industrialized. Town officials have expressed the intention of zoning the area against residential settlement. It may be concluded that the general run-off characteristics will not be changed drastically.

The built-up area of 530 acres is, for all practical purposes, fully developed. The limits of this portion of the drainage area are fixed by natural topography and existing sewer systems. There is no possibility of increasing the drainage area by extending the sewer system.

B. Sewer Facilities. - As mentioned in the foregoing discussion, the town of East Hartford maintains a separate sanitary sewer system in the developed area. Reference is made to Plate 4 and Plate 5 showing the sewer layout.

1. Existing sewers. - Under existing conditions the sewer system, wherever constructed, is adequate. Storm drains serving the area on the flat top of bluff (commercial and residential section) have outfalls at several points along the bluff. If, however, the capacity of the storm drains is exceeded by prolonged intense precipitation, i.e., a storm greater than the one selected for the design of the sewers, it is possible for the excess run-off to flow over the surface and into the swale. The sanitary sewage from the area served by the Meadow Hill pumping station is collected by a single intercepting sewer running along Prospect Street. This 30-inch sewer discharges into the Hockanum River.

2. Future development. - According to local authorities the present storm drains, in areas now sewered, will not have to be

enlarged to meet future development. The extent to which the swale area is to be provided with drains in the future is highly unpredictable as it depends upon the type of development which will obtain. Sanitary sewers, in areas now sewered, have ample capacity for present and future conditions.

C. Seepage. - The foundation underlying the dike is of varying permeability. Seepage through the pervious formation will be prevented by a sheet pile cut-off. The quantity of seepage to be expected through the dike and its foundation at maximum head will be small. Suitable toe drains are constructed to collect all such seepage.

D. Storage. - Natural surface and valley storage must be taken into consideration since it has a pronounced effect on the discharge hydrograph. The drainage area under consideration has rather slow run-off characteristics since the ground surface is quite flat. In addition to this characteristic, there exists in the swale a certain amount of valley storage which has a further delaying effect on the peak discharge produced by storm run-off.

A drainage area of 980 acres is capable of yielding high peak discharges even for moderately heavy storms. It is usually highly desirable to create a storage pond for the purpose of reducing the peak flow. Conditions at East Hartford are ideally suited to the excavation of such a storage pond. The size of pond is governed by economic and other considerations discussed under another section of this design analysis.

III. DETERMINATION OF DISCHARGE CAPACITY

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A. Requirements for Discharge Capacity. - The pumping station will be of sufficient capacity to meet the following requirements:

1. Discharge the storm run-off from the total tributary drainage area.

2. Discharge all seepage entering the area through the dike and foundation.

3. Discharge the sanitary sewage from the area.

4. Hold the water surface elevation in the storage pond at or below elevation 10 feet m.s.l. under the assumed maximum conditions of run-off and river stage.

Two separate analyses of storm run-off (Item 1) are made, one assuming that no storage is available, and the other showing the effect of storage in reducing the peak flow.

a. No storage available. - An analysis on this basis was made in order to demonstrate that the governing condition of pumping rate versus river stage occurs in the summer months, when low river stages may be expected. In other words, the slope of the envelope curve (Plate 9) is such that any pump capable of discharging the storm run-off with the Connecticut River at "maximum zero damage stage" will also handle the run-off at any other stage. Two conditions are assumed:

(1) Run-off caused by a 2-hour storm (time of concentration of this area is approximately two hours) with a probable frequency of occurrence of once in 10 years, occurring in any month, when pumping against a river

stage with a probable frequency of occurrence of once in 10 years for that month.

(2) Forty percent of the run-off caused by a 2-hour storm with a probable frequency of occurrence of once in 10 years, occurring in any month, when pumping against a river stage with a probable frequency of occurrence of once in 1000 years for that month.

b. With storage pond. - The provision of a storage pond is not only feasible but highly desirable from the standpoint of economy and operation. The analysis made herein makes it possible to compute the effect of a storage pond on the required pump capacity. The assumption is:

(1) Run-off caused by an 8-hour storm (a storm of this duration includes all significant precipitation) with a probable all-year frequency of occurrence of once in 10 years, when pumping against a river stage of 10 feet above mean sea level.

B. Storm run-off analysis if storage pond is not provided. - Assuming that no appreciable storage capacity is available, i.e., whatever natural storage exists in the swale is eliminated by future development of the area, and no artificial storage pond is created, the pumps would be required to handle the peak storm run-off.

1. Rainfall. - Monthly rainfall intensity-frequency curves were drawn for 2-hour storms from the 35 years of rainfall records at Hartford, Conn. (Plate 6). From these monthly curves, the 2-hour intensity with a frequency of 10 years was determined and related to the 10-year river stage.

2. Run-off coefficients. - From a study of the average monthly run-off for nearby watersheds, it was found that the run-off coefficients for the months of November, December, January, February, March, and April were high, and were therefore grouped together. The run-off coefficients for the months of May, June, July, August, September, and October were found to be relatively low, and were grouped together. The following table shows the run-off coefficients which were selected for the various types of area. These coefficients were weighted according to the amount of each type of development, to obtain weighted run-off coefficients for the entire area for the winter and summer months.

Run-off Coefficients

Season	Run-off coefficient		Weighted run-off coefficient
	Commercial and residential 530 acres	Undeveloped 450 acres	980 acres
November through April	0.75	0.30	0.54
May through October	0.50	0.20	0.36

3. Frequency of river stages - The monthly stage-frequency curves of the Connecticut River at East Hartford, Conn., shown on Plate 7, supply the 10-year and 1000-year frequency stages for each month. Plate 8 shows the stage-duration curve for the Connecticut River at East Hartford.

4. Required discharge capacity for surface run-off. -

The run-off from the area was determined by the use of the formula:

$$Q = C\ I\ A$$

in which

Q = discharge from the total drainage area in c.f.s.;

C = the weighted run-off coefficient;

I = intensity in inches per hour for the 2-hour storm;

A = total drainage area tributary to the pumping station, in acres.

The following table shows the relationship between the rate of run-off and the corresponding river stage.

Month	2-hr. 10-yr. intensity, in inches per hour	Weighted run-off coeff.	Run-off c.f.s.	Connecticut River stage (m.s.l.)		40% of 10-yr. run-off c.f.s.
				10-year	1000-year	
Jan.	0.42*	0.54	222	13.9	23.3	89
Feb.	0.34*	0.54	180	15.7	27.8	72
Mar.	0.37	0.54	196	23.2	40.2	78
Apr.	0.38	0.54	201	23.5	28.9	80
May	0.45	0.36	159	18.6	22.2	64
June	0.66	0.36	233	14.1	21.5	93
July	0.83	0.36	293	9.9	21.3	117
Aug.	0.88	0.36	311	8.5	20.3	124
Sept.	0.70	0.36	247	10.2	34.9	99
Oct.	0.50	0.36	177	12.4	33.3	71
Nov.	0.40	0.54	212	14.1	30.8	85
Dec.	0.39*	0.54	206	16.2	25.4	82

* Rainfall intensity from Providence, R. I. records.

The variation in storm run-off with river stage is illustrated graphically on Plate 9.

C. Storm run-off analysis if storage pond is provided. - It is feasible to create a storage pond at this site. In order to show the effect of storage capacity on the required pump capacity, it is necessary to construct a storm hydrograph which will represent the regimen of inflow. The analysis as established in subsequent discussion is based on the unit hydrograph method of storm construction. The entire procedure is somewhat handicapped by the absence of gaging records for the drainage area in question. Nevertheless, with careful conservative selection of factors which are dependent upon the characteristics of the drainage area, and which define the regimen of flow, it is possible to get results sufficiently accurate for all practical purposes.

1. Rainfall. - Precipitation several hours in duration was to be used in the construction of the storm hydrograph. In previous studies 35 years of rainfall records at Hartford, Connecticut, had been analyzed to determine the yearly, 2-hour, 10-year rainfall intensity (2.10"). The records, however, were not broken down to reveal rainfall intensity for storms of greater duration, nor was such a lengthy computation considered warranted. As a rapid expedient a "Mass Rainfall Curve" (total rainfall vs. duration) was drawn from data presented in Misc. Pub. #204, U.S.D.A. "Rainfall Intensity - Frequency Data", by D. L. Yarnell. Proportional to that curve and through the above mentioned value (2.10"), another curve was drawn, thus giving a "Mass Rainfall Curve" suitable for use in these studies. Reference is made to Plate 10. Since a period of 8 hours includes

all significant rainfall, a storm of that duration was selected to be applied to the unit hydrograph. The following table gives the rainfall as read from the curve:

Hours	Total rainfall in inches	Rainfall in any 2-hour period in inches
0	0	2.10
2	2.10	0.52
4	2.62	0.33
6	2.95	0.23
8	3.18	

2. Run-off. - There are several factors which influence the selection of a run-off coefficient. This coefficient may be defined as a decimal stating the portion of rainfall that passes through drains or over the ground surface to the point of discharge. That portion of the rainfall that soaks into the ground and becomes ground water is hereinafter referred to as infiltration. Consideration was given to the pervious nature of the soil, the likely condition of the soil at the beginning of the storm, and the state of development of the area. A good average run-off coefficient for the entire watershed is derived if it is assumed that 50% of the total rainfall (3.18") will appear as run-off. This gives a maximum infiltration of 0.26 inches per hour. This is illustrated graphically on Plate 11.

3. Unit hydrograph. - As defined, the unit hydrograph is the discharge hydrograph resulting from a run-off of one inch on the drainage area. For convenience a 2-hour unit hydrograph is used. In so far as no gaging records are available the basic graph is determined by estimating the factors that define the regimen of flow. These factors are:

a. Time of concentration. - This period, for any watershed, is the time required for a given particle of water from the most remote part of the watershed to reach the point of exit. If rain continues falling over the entire watershed until this remote particle reaches the outlet, maximum discharge will occur at that instant, since all parts of the watershed will then be simultaneously contributing to the flow. For the case at hand the maximum length of travel is 13,100 feet. The water travels through drains for about one-half of this distance, and through an open ditch for remaining distance. By estimating the velocities in the various sections, it is possible to compute the time of travel. Adding to this an "inlet time" of 20 minutes, the time of concentration was found to be approximately two hours.

b. Peak discharge. - The maximum instantaneous discharge of the unit hydrograph, resulting from one inch of run-off in two hours, is dependent upon the character and slope of the surface. The formula

$$Q = K I A$$

where

Q = rate of run-off in cubic feet per second;

K = a coefficient which introduces the influence of drainage area characteristics;

I = volume of run-off in inches per hour (0.5 in./hr. in this case);

and

A = drainage area in acres;

is used to compute the peak discharge. A reconnaissance of the watershed reveals that the area, because of its flatness, may be expected to have "slow" rather than "flashy" run-off characteristics. A "K" value of 0.5 was selected as a fairly representative figure.

c. Base of hydrograph. - The base of the unit hydrograph was arbitrarily selected as 8 hours.

d. Total volume. - By definition the unit hydrograph must show that the total run-off volume is one inch on 980 acres.

The unit hydrograph resulting from the above procedure is shown on Plate 10. It has a peak discharge of 245 c.f.s.

4. Storm hydrograph. - Having determined the rain graph and the unit hydrograph, it is simply a matter of calculation to compute the resulting storm hydrograph. The computation is as follows:

Period (hours)	Unit Graph Values (c.f.s.)	Storm hydrograph resulting from 1.59 inches of run-off (c.f.s.)
0	0	0
0.5	62	99
1.0	150	238
1.5	220	350
2.0	245	390
2.5	240	382
3.0	224	356
3.5	200	318
4.0	170	270
4.5	138	220
5.0	110	175
5.5	86	137
6.0	63	100

Period (hours)	Unit Graph Values (c.f.s.)	Storm hydrograph resulting from 1.59 inches of run-off (c.f.s.)
6.5	41	65
7.0	22	35
7.5	8	13
8.0	0	0

The storm hydrograph is shown on Plate 11. The general procedure has produced a well rounded hydrograph, which is as it should be for a drainage area with flat slopes and considerable natural storage.

D. Required discharge capacity for sewage. - The problem of handling sanitary sewage is influenced by the fact that the town of East Hartford is considering a plan of sewage treatment. Some time, however, will probably elapse before such a plan is put into effect, and provision for pumping sanitary sewage is therefore necessary. After thorough consideration (including consultation with town officials), it was decided that sufficient capacity for the immediate future was justifiable. Under the circumstances allowance for development far into the future is not warranted.

As brought out in foregoing discussion, the town maintains a separate sewer system. The existing 30-inch intercepting sewer running along Prospect Street, and discharging into the Hockanum River, collects all the sewage from the area tributary to Meadow Hill pumping station. An area of approximately 1100 acres is served by the sanitary sewers. An analysis to determine the maximum flow is made on the following basis:

Population	= 25 persons per acre
Domestic sewage	= 200 gal. per capita per day
Groundwater infiltration	=3000 gal. per acre per day

Computation shows the flow to equal 13.6 second feet. This indicates that the intercepting sewer, with a slope of .0024 and a capacity of 20.5 c.f.s., is more than adequate. Since the allowances made are generous, a pump capable of expelling 14 c.f.s., against maximum head, is considered sufficient.

E. Required discharge capacity for seepage. - From a brief consideration of the magnitude of the various quantities involved and the basis for computation of such quantities, it is obvious that seepage is an insignificant quantity. It would be inconsistent with the over-all accuracy of the problem to include a figure for seepage, hence no further consideration is given to it.

F. Required pump capacity. - Since a storage pond is to be incorporated in the scheme for handling storm run-off, it is necessary, for reasons of sanitation, to provide separate pumps for storm water and sanitary sewage.

1. Sewage pump. - In so far as the maximum flow will not exceed 14 c.f.s., even in the near future, a pump to expel that amount at maximum head is adequate. This figure is predicated on the assumption that added capacity to care for extensive future development is unnecessary because of the plans for sewage treatment. Town officials are convinced that sewage treatment will be effected in the near future. When such a plan materializes, the need for handling raw sewage will disappear. A bypass is provided to permit sanitary flow to enter the wet sump and be discharged by the storm pumps.

2. Storm-water pumps. - The size of pumps required to expel the storm run-off varies with the amount of storage capacity.

Theoretically, according to the design criteria set up in this analysis of design, it would be possible to store the entire run-off (1.59 inches on 980 acres) by providing 130 acre-feet of storage. It is not practical to do this, however, since a minor storm may follow the design storm while the Connecticut River is still at flood stage. It follows that a minimum pump capacity is necessary even if the total volume of storm run-off is stored.

With the storm hydrograph constructed it is possible to compute the storage capacity necessary for any particular pumping rate. For example, if it is assumed that installed pumps have a discharge capacity of 200 c.f.s., the amount of storage required is determined by measuring the volume of the storm hydrograph above that pumping rate. With several points determined in this manner, a curve of pumping rate vs. storage capacity is thus defined. Such a curve has been constructed for the Meadow Hill pumping station, and is shown on Plate 11. Values taken from this curve are as follows:

Total storage capacity (acre-feet)	Required pumping rate (cu. ft./sec.)
20	265
40	196
60	140
80	92

It has been pointed out that under existing conditions the swale is a natural storage basin. Approximately 27 acre-feet of natural storage is available below El. 10.0 at the present time. Since

it will probably be several years before development will eliminate this natural storage, it would be perfectly feasible to take advantage of it. This could be done by building the pumping station to eventually accommodate pumps to go with a created storage pond of a certain capacity, but for the present time install pumps to go with the created plus natural storage. The use of this natural storage meets with the approval of the officials of the town of East Hartford.

G. Installed Pump Capacity. - Cost estimates and studies of operation requirements reveal that it is economically and practically desirable to create a storage pond having a capacity of 40 acre-feet. The size of pumps to be installed is dependent upon several factors. Naturally, the maximum estimated inflow and the capacity of the storage pond are the first considerations. However, such items as flexibility of operation, a factor of safety to insure mechanical reliability, and available stock sizes also influence the selection. Under the circumstances (refer to foregoing paragraph) it is feasible to utilize the existing 27 acre-feet of natural storage capacity in addition to the created storage capacity of 40 acre-feet, thus making a total initial storage capacity of 67 acre-feet. It was the original intention to provide an initial pump installation of three 30" propeller pumps, with provision for a fourth pump which could be installed ultimately if and when the natural storage of 27 acre-feet is eliminated. A review of the pumping requirements, made in the North Atlantic Division Office, indicated that the initial capacity required in conjunction with 67 acre-feet of storage would be approximately the same as the ultimate capacity (corresponding to 40 acre-feet of storage) as proposed by this

office. The Division's recommendation was, therefore, to install four 30" propeller pumps initially and to make no provision for future increases. The Office of the Chief of Engineers concurred in this recommendation. The characteristics of the pumps to be installed are shown on Plate 12. It will be noted that the small pump, which is to handle the sanitary sewage, will expel 15 c.f.s. when pumping against maximum head.

H. Gravity Flow Conduit. - When the Connecticut River is low, drainage of the area tributary to the Meadow Hill Pumping Station will take place by gravity flow. Storm run-off and groundwater collected by the swale will pass through the gravity flow conduit (under the dike) and into the Hockanum River.

The conduit was designed to have a capacity at least great enough to discharge the peak flow (390 c.f.s.) of the storm hydrograph shown on Plate 11 without exceeding a pond level of elev. 10.0 m.s.l., and with the Connecticut River at low stages. This requirement neglects the effect of storage capacity in the pond, in reducing the peak of the inflow hydrograph. Were this storage taken into consideration, it would be possible for the inflow hydrograph to have a maximum peak discharge considerably in excess of 390 c.f.s. without exceeding the limiting pond elevation.

Computations indicate that a rectangular conduit 6 feet wide and 8 feet high will furnish adequate capacity. The invert of the conduit is to be elev. 1.5 at the entrance, and elev. 1.0 at the outlet. Its slope of 0.0022 is not steep enough to maintain super-critical velocities. The hydraulic elements have been plotted on Plate 13. To

further illustrate the capacity of the conduit, rating curves are shown on Plate 14. With the pond at elev. 10.0, the maximum capacity of the conduit is 410 c.f.s. For this condition, flow takes place as in an open channel. If the conduit is flowing full throughout its entire length, a head differential of 2.15 feet is required to discharge 410 c.f.s.

During flood stages, when the pumping station is in operation, the gravity flow conduit will serve to carry the discharge from the pumps to the river side of the dike.

IV. SOIL INVESTIGATIONS

IV. SOIL INVESTIGATIONS

A. Foundation conditions. - Foundation was investigated by two 2-1/2" bore holes and two foundation auger holes. Additional information was obtained from two nearby 6" bore holes used for undisturbed sampling. Location of explorations and foundation conditions are shown on Plate No. 15 and on Plate No. 16. Numbers in boring logs on section are those of the Providence District Soil Classification shown graphically on Plate No. 17 and described in Table No. 1. Foundation consists of a natural silt blanket (Classes 6-8, 6 and 13-11) 20 to 30 ft. thick overlying a layer of medium to coarse sand (Classes 2, 6-4 and 5) 5 to 15 ft. thick. Beneath is a 60 ft. bed of reddish-brown varved clay with an average natural void ratio of 1.56 and a water content between 40% and 60% which is about equal to or slightly greater than liquid limit. Results of a typical consolidation test are shown on Plate No. 18 and Plate No. 19. Values of the preconsolidation load, determined from consolidation tests, indicate that this clay has supported an overburden load in past greater than present. This past load has been estimated as that due to an old land surface at about elevation 36 which represents a continuation of the present bluffs on which the City of East Hartford is located. Underlying the clay is a layer of compact glacial till about 5 ft. thick resting upon rock.

B. Laboratory investigations. - Laboratory tests were confined to classification of foundation materials, permeability and consolidation tests. Grain size curves were obtained by sieve and hydrometer tests run on representative samples for each stratum encountered. These samples were classified in accordance with Providence District Soil Classification.

Results of consolidation tests on undisturbed samples of varved clay from two nearby 6" bore holes were used in this analysis.

C. Settlement. - Settlement of station and conduit will occur due to consolidation of clay in foundation under dike and station loads. Because of preconsolidation settlements due to reloading up to preconsolidation load will be fairly small; beyond this point the settlement will be much greater. Loads due to dike and station were substituted by simplified triangular and rectangular loads respectively. Allowance was made for effect of excavation release from station and outlet channel excavation and for effect of hydro-static uplift on station giving a net dead load of station of 0.11 tons per sq. ft. Stresses in soil were determined using charts prepared by Jürgensen and Newmark which are based upon elastic theory for isotropic material. Settlements were computed from the relation

$$\Delta H = \frac{a_v \Delta p H}{1+e}$$

where ΔH = settlement

H = thickness of clay

Δp = average load increase in clay

a_v = coefficient of compressibility determined from consolidation tests

e = void ratio of clay

From results of consolidation tests average a_v was determined as:

for loads less than preconsolidation load
1.2×10^{-5} on $^2/gr.$

for loads greater than preconsolidation load
6.6×10^{-5} on $^2/gr.$

Estimated settlements were calculated for 4 points as located on Plate No. 16 and are tabulated below.

POINT	LOCATION	ESTIMATED SETTLEMENT (ULTIMATE)
A	Conduit at ℄ of dike.	7-1/2" ± 25%
B	Gate structures ℄ of conduit.	1" ± 25%
C	Southwest corner of Pumping Sta.	2" ± 25%
D	Northwest corner of Pumping Sta.	1" ± 25%

Settlements will occur moderately rapidly for clay: 50% of ultimate settlement in 1 year and 90% in 4 years. Estimated rate is based on actual rate of observed settlement of South Meadows Electric Station which rests on this same clay. Those settlements are due to consolidation of clay only. Excavation in silt for conduit and station will be carried about 5 to 8 ft. below present water table. Careful water control will be required to prevent formation of a quick condition which would loosen foundation soil and cause increased settlement from recompaction of loosened silt. Settlement observations will be taken on points in conduit and at corners of pumping station.

TABLE NO. 1

PROVIDENCE SOIL CLASSIFICATION
U. S. ENGINEER OFFICE
PROVIDENCE, R. I.

CLASS	DESCRIPTION OF MATERIAL
1	Graded from Gravel to Coarse Sand. - Contains little medium sand.
2	Coarse to Medium Sand. - Contains little gravel and fine sand.
3	Graded from Gravel to Medium Sand. - Contains little fine sand.
4	Medium to Fine Sand. - Contains little coarse sand and coarse silt.
5	Graded from Gravel to Fine Sand. - Contains little coarse silt.
6	Fine Sand to Coarse Silt. - Contains little medium sand and medium silt.
7	Graded from Gravel to Coarse Silt. - Contains little medium silt.
8	Coarse to Medium Silt. - Contains little fine sand and fine silt.
9.	Graded from Gravel to Medium Silt. - Contains little fine silt.
10	Medium to Fine Silt. - Contains little coarse silt and coarse clay. Possesses behavior characteristics of silt.
10 C	Medium Silt to Coarse Clay. - Contains little coarse silt and medium clay. Possesses behavior characteristics of clay.
11	Graded from Gravel or Coarse Sand to Fine Silt. - Contains little coarse clay.
12	Fine Silt to Clay. - Contains little medium silt and fine clay (colloids). Possesses behavior characteristics of silt.
12 C	Clay. - Contains little silt. Possesses behavior characteristics of clay.
13	Graded from Coarse Sand to Clay. - Contains little fine clay (colloids). Possesses behavior characteristics of silt.
13 C	Clay. - Graded from sand to fine clay (colloids). Possesses behavior characteristics of clay.

V. GENERAL DESIGN

V. GENERAL DESIGN

A. Selection of site. The general location of Meadow Hill Pumping Station was fixed for the vicinity of the intersection of the swale and the dike. Three sites were studied and the location selected was finally determined by the most important factor of foundation conditions. The sub-soil at the swale and immediately eastward consists of plastic clay of great depth. From the swale and westward, there is a layer of silt and sand having a total depth of 35 feet or about a 20-foot depth below the base slab of the pumping station.

B. Alternative layouts

1. To determine the layout of the pumping station and its appurtenant structures having the most advantages, trial layouts were made. A plan utilizing the structure as an integral part of the dike had the apparent economy of saving a portion of the embankment and eliminating the conduit. However, the large wingwalls required and the problems of settlement and seepage resulting, made this scheme unattractive.

2. The layout adopted provides a superior design at a considerable saving in construction costs. The pumping station, being located on a berm adjacent to the dike is in a zone where settlement is small, thus eliminating a serious problem. The presence of a natural blanket under the dike and outlet channel makes a sheet pile cut-off unnecessary.

C. Design features

1. Storage pond. - The storage pond is provided to reduce peaks in the hydrographs resulting from rainfall. Normally, the pond will remain at the same elevation as the river. The pumps will be used as often as

necessary to keep the pond drawn down only when the river is above elevation 10.0. A channel is provided from the swale across the pond to the pumping station. The grades of the bottom of the pond and the intake channel are such that the flow of water to the pump is facilitated at low stages. No mosquito nuisance is anticipated.

2. Intake structure. - The intake structure consists of a section of concrete channel provided with stop-log slots, gates and trash racks. The area immediately upstream of and adjacent to the intake is lined with riprap on a gravel base. The gravel base and riprap will permit the harmless passage of ground water in the event seepage becomes concentrated at this point. The trash racks are of the fixed type, separate racks being provided for the flow through the conduit and into the sump. Bar spacing is 7" center to center where the flow is directly through the conduit and 3" center to center when the flow is diverted through the pumps. All bars are 4" x 3/8" with round edges. In the pump flow side, a drop of 2-1/2 feet is provided in order to furnish adequate cross section to conserve head.

3. Conduit. - The conduit is provided to pass flow from the protected area under the dike to the river. When the river is low the flow is discharged by gravity. In flood times the flow is diverted by means of the gates into the wet sump from where it is discharged into the conduit by the pumps. The conduit under the dike is provided with seep rings and expansion joints at intervals. In order to hold the conduit in line when settlement occurs the seep rings at the expansion joints are constructed in bell and spigot fashion for holding adjacent monoliths in alignment. Rubber water stops are provided in the joints to prevent leakage.

The service bridge is supported on piers which in turn rest on the conduit. Backfill around and above the conduit will be compacted impervious material to insure a minimum of seepage and prevent piping along the structure.

4. Outlet structure. - The down stream end of the conduit is provided with an outlet structure with hand operated seating pressure sluice gate. The gate is for the purpose of blocking the conduit in an emergency. Riprap is put in at the end of the outlet structure to prevent scouring by jet action and eddies.

5. Service bridge. - A structural steel service bridge is provided connecting the top of dike and the outlet structure. It is made up of two spans, each about 30 ft. long. Two 18" channels support a floor grating and hand rails. The bridge is intended for pedestrian access only. It will support a load of about 100#/ sq. ft. without excessive deflection.

VI. MECHANICAL DESIGN

VI. MECHANICAL DESIGN

A. Pump drive. - The Meadow Hill Pumping Station is one of three pumping stations to be constructed in East Hartford, Conn. Prior to the design of any of the stations, an investigation was made of the type of drive to be employed and after conference with the town officials, it was decided that gasoline engines should be used for driving the flood water pumps.

The gasoline engines for the Meadow Hill Pumping Station will be of the heavy-duty industrial type capable of continuously driving the pumps at their rated speed under any head condition developed. The engines will not use over 85 percent of their developed horsepower. They will be mounted on concrete bases and directly connected through flexible couplings to the right angle gear units.

The 20-inch sewage pump will be operated by an electric motor utilizing commercial power. This type of drive was adopted as most suitable because the pump will be operated for extended periods of time and an electric motor drive can be maintained and operated with little difficulty. The motor will be of the wound rotor induction type with control arranged to provide for 1/2, 3/4 and full speeds. This type was employed to reduce the size of the gasoline-electric standby unit and to eliminate stop-and-start operation under low flows. Should the commercial power supply fail, power for operation of the pump will be obtained from the gasoline-electric standby unit.

B. Pumps. - From the ultimate required pumping capacity of 196 c.f.s. as determined in Section III., it was determined that provisions should be made to install four pumps. To install a larger number of pumps would

materially increase the cost of the station without resulting in any great advantage and a smaller number would seriously limit the operating flexibility and reliability of the station.

No provisions were made in the capacity determined in Section III for possible mechanical failure of equipment. To provide for this contingency, it is considered necessary that any three pumps should be capable of delivering about 80 percent of the 196 c.f.s. or 156 c.f.s. This factor will make an ultimate station capacity with four pumps operating at full efficiency, of 208 c.f.s. A study of equipment indicated that four 30-inch propeller type pumps would be required; each pump to have a capacity of 23,000 g.p.m. or 52 c.f.s., against a total head of 10 feet. In addition, one 20-inch mixed flow type of pump having a capacity of 7,000 g.p.m. against a total of 30.0 feet was provided to pump the sanitary sewage at such periods when the river is at flood stage.

C. Right angle gear units. - The gear units will be of the self-contained type designed for transmitting the power from the horizontal engine shaft through a gear train to the vertical pump shaft. The units will be inclosed in a cast iron and structural steel housing and will have a service factor of not less than 1.25 times the maximum power required to drive the pumps under any condition of head.

d. Standby generator unit. - A gasoline engine-driven generator will be provided to furnish electric power at 208 volt, 3 phase and 120 volt, single phase in the event of failure of commercial power. The unit will have a normal full-load capacity of 125.0 kva, which will be sufficient to start and run the 20-inch pump motor as well as maintain in operation the other electrical auxiliaries and the station lighting system.

E. Crane. - A five-ton overhead crane will be installed in the engine room to facilitate the repairing of any item of equipment. The crane will be of standard construction and hand operated throughout.

F. Sluice gates. - A motor-operated sluice gate will be located at the entrance to the pump sump. This gate will normally be kept closed to prevent water from collecting in the sump. It will be opened only at such periods when it is necessary to operate the storm water pumps. A second motor-operated sluice gate will be located in the gravity discharge conduit at a point between the pump discharge and the pump sump intake. This gate will normally be kept open to permit water to flow by gravity to the river. It will be closed only at such times when it is necessary to prevent back flow from the river. A hand operated sluice gate will be located at the discharge end of the gravity flow conduit. This gate will normally be kept open to permit sewage and storm water to discharge into the river. It will be closed only in case of emergency or at such time that it is necessary to make repairs to the conduit.

G. Water system. - The town water supply will be connected to the pumping station and the water used for cooling the gasoline engines and station service. In addition, the sump pump will be so connected that it can be employed to furnish engine-cooling water in times of emergency.

H. Gasoline system. - Gasoline will be stored in a 3200 gallon tank buried in the ground adjacent to the pumping station. Each engine will be supplied through an individual line running directly to the tank. Drip pans will be provided on each engine and connected to a common header running back to the tank. All gasoline pipe will be 3/4-inch, I. D. copper tubing with flared joint connections. At such points where the gasoline lines are imbedded in concrete or pass through beams, they will be protected by wrought iron pipe sleeves.

I. Sump pump. - A motor-operated sump pump of 50 g.p.m. capacity will be provided in the wet sump for the purpose of drying it up after the pumping station has been in operation.

J. Valves. - A swing check valve will be installed in each pump discharge line to facilitate the starting of the pump and to prevent back-flow when the river is at flood stage. A gate valve will be provided in each discharge line so that they may be closed should the check valve fail to close.

K. Fire extinguishing system. - A carbon dioxide fire extinguishing system will be installed and so arranged that any gasoline engine can be blanketed with gas by tripping a valve located just inside the main entrance to the building. Portable extinguishers will be provided to take care of any other emergencies.

L. Heating system. - The heating system will be of the two pipe gravity type consisting of an oil-fired boiler supplying steam to two unit heaters located at opposite ends of the engine room. The oil burner will be of the rotary type with electric ignition. The unit heaters will be of ample capacity to heat the engine room under the coldest weather condition.

M. Power source. - Power requirements for the station will be approximately 70 KW. Power will be delivered to the station at 115/230 volts, three phase, 60 cycle over a four wire grounded neutral system, through a bank of "T" connected transformers. From the transformers power will be taken to the station through an underground feeder.

N. Switchboard and control equipment. - The switchboard will be of the dead front, steel enclosed, low-voltage type with all controls and meters flush mounted on the front. All air circuit breakers will be

manually operated. Circuit breakers for the incoming feeder and standby generator will be rated at 600 volts, 60 cycle A.C. having an interrupting capacity of 25,000 amperes, provided with instantaneous and time-delay magnetic overcurrent trips and interlocked so that only one breaker can be in the closed position at any one time. All breakers operating three phase circuits will be rated 600 volts, 60 cycle A.C. of suitable ampere ratings.

The 20-inch wound rotor pump motor circuit will have a magnetically operated, push button actuated, switch for the primary circuit and a drum controller with suitable resistors for the secondary circuit. The control circuit to the magnetic starter will be interlocked through the drum controller so that the motor can be started only when the drum controller is in the off position. The resistors will be mounted on the wall near the switchboard and will be suitable for continuous running duty on any point. A voltage regulator and battery charger will be located inside the switchboard. Instruments on the board will consist of an indicating watt meter, voltmeter, ammeter and independent D.C. ammeters to read the charging rates to the various batteries.

Two distribution panelboards will be installed in the station, one in the boiler room and one in the engine room to distribute power to the various light, receptacle, fan and heater circuits.

VII. STRUCTURAL DESIGN

VII. STRUCTURAL DESIGN

A. Specifications for structural design

1. General. - The structural design of the Meadow Hill pumping station has been executed in general in accordance with standard practice. The specifications which follow cover the conditions affecting the design of the reinforced concrete and structural steel.

2. Unit weights. - The following unit weights for material were assumed in the design of the structure:

Water	62.5# per cubic foot
Dry earth	100 # per cubic foot
Saturated earth	125 # per cubic foot
Concrete	150 # per cubic foot

3. Earth pressures. - For computing earth pressure caused by dry earth Rankine's formula was used. For saturated soils an equivalent liquid pressure of 80 pounds per square foot per foot of depth was assumed.

4. Structural steel. - The design of structural steel was carried out in accordance with the Standard Specifications for Steel Construction for Buildings of the American Institute of Steel Construction.

5. Reinforced concrete. - In general, all reinforced concrete was designed in accordance with the "Joint Committee on Standard Specifications for Concrete and Reinforced Concrete" issued in January 1937.

a. Allowable working stress. - The allowable working stress in concrete used in the design of the pump house and appurtenant structures is based on a compressive strength of 3,000 pounds per square inch in 28 days.

b. Flexure (f_c). - Lbs. per sq. in.

Extreme fibre stress in compression ... 800

Extreme fibre stress in compression adjacent to supports of continuous or fixed beams or rigid frames 900

c. Shear (v). -

Beams with no web reinforcement and without special anchorage 60

Beams with no web reinforcement but with special anchorage of longitudinal steel 90

Beams with properly designed web reinforcement but without special anchorage of longitudinal steel 180

Beams with properly designed web reinforcement and with special anchorage of longitudinal steel 270

Footings where longitudinal bars have no special anchorage 60

Footings where longitudinal bars have special anchorage 90

d. Bond (u). -

In beams, slabs, and one way footings 100

Where special anchorage is provided .. 200

The above stresses are for deformed bars.

e. Bearing (f_c). -

Where a concrete member has an area at least twice the area in bearing 500

f. Axial compression (f_c). - Lbs. per sq. in.

Columns with lateral ties 450

g. Steel stresses. -

Tension 18,000

Web reinforcement 16,000

h. Protective concrete covering. -

Type of members	Minimum cover in inches
Interior slabs	1-1/2
Interior beams	2
Members poured directly against the ground	4
Members exposed to earth or water but poured against forms	3

For secondary steel, such as temperature and spacer steel, the above minimum cover may be decreased by the diameter of the temperature or spacer steel rods.

B. Basic assumptions for design.

1. Roof slab. - The roof slab is of reinforced concrete. It is designed to carry the full dead load plus a live load of 40 # per square foot of roof surface.

2. Roof beams. - The roof beams are of structural steel encased in concrete fireproofing. They are designed to carry the full dead load, plus the full live load of 40# per square foot of roof surface. In addition to taking up the roof load, these beams together with the columns to which they are connected, form portal frames which take up wind load and crane thrusts on the building. The end connections are designed to take up all such horizontal loads.

3. Columns. - a. Structural steel columns in the side walls and end walls of the superstructure take up the direct roof loads as well as all wind loads on the sides of the superstructure. In addition, the columns in the side walls carry crane brackets which support the crane runway. These columns are designed to carry full live and dead load from the roof; dead load, live load, and impact effect from the traveling crane; bending due to eccentrically applied loads, and bending due to wind load on the building. No point of inflection was considered in the column design, a pin-ended condition at the base being assumed.

b. Wall columns in the ends of the building were designed for full dead load and live load from roof, plus wind load on the building.

c. Allowable stress in columns were figured from formula with a maximum allowable stress of 15,000# per square inch for dead load plus live load, and a maximum allowable stress of 20,000# per square inch for combined dead load, live load, and wind load; l/r limited not to exceed 120.

$$P/A = \frac{18,000}{1 + \frac{l^2}{18,000 r^2}}$$

4. Engine room floor. - The engine room floor is designed to carry all engines, motors, etc., actually to be placed on that floor, as well as a uniform load.

The following assumptions were made for design purposes:

a. For the floor slab, the design loads are the estimated dead loads plus a uniform live load of 250# per square foot.

b. For the removable steel floor plates, the design loads are the estimated dead load plus a uniform load of 300# per square foot.

c. For the floor beams, the design loads are the estimated dead loads, the actual machinery loads, a concrete base slab load under the gasoline engines, and a uniform load of 200# per square foot on the unoccupied portion of the floor slabs which contribute loads to the beams under consideration. For the machinery loads, an impact factor of 100 percent has been added.

5. Pump room side walls. -

a. The walls are designed of reinforced concrete below elevation 21.5 and of brick and steel construction above elevation 21.5.

b. In the wet pump room side walls, to provide for horizontal pressures, the walls were designed simply supported at the engine room floor level and continuous with the pump room floor. At the engine room floor level the walls are supported by the floow slab acting as a horizontal girder which transfers the reactions into the end wall and the division wall between the wet and dry pump rooms.

c. In the dry pump room, the end wall and base slab were designed as a continuous frame, with the end wall simply supported at the engine room floor and at the boiler room floor, and base slab simply supported under the division wall. The side walls were designed as simply supported at the top and fixed at the base.

d. The loading consisted of the vertical loads due to the weight of the structure; the vertical live and impact loads from the engine room floor; the roof live load; and the thrusts against the walls from earth pressures.

From the loadings noted, bending moments were computed in the walls, pump room floor slab and engine room floor beams.

6. Pump room end walls. - The pump room end walls were designed to resist the vertical loads, and thrusts due to earth pressure.

7. Boiler room floor. - The boiler room floor was designed for a uniform live load of 100# per square foot plus the dead weight of slab.

8. Conduit. - The conduit is designed as a continuous box section for internal pressure as well as earth pressure. The gate chamber frame is designed with members fixed at both ends. An expansion joint is provided between the intake structure and the pump house substructure. The conduit at the west side of the pump house is part of the substructure and an expansion joint is provided at the south end of the house.

9. Trash racks. - There are three trash racks in all, two in the gate chamber and one at the sanitary sewer entrance. The rack at the intake to the wet pump room is made in two sections while the other two are each made in one section. All three are held in place by gravity and rest in a seat at the bottom.

10. Stairways and ladders. - An open grating stairway leads from the engine room floor to the boiler room and then to the dry pump room. Access to the wet pump room is obtained by means of a concrete stairway. Steel ladders are provided in the intake chambers, the rack chamber, and in the conduit outlet structure.

C. Architecture. - The pumping station will be a building of modern design in keeping with the architectural treatment used on similar projects elsewhere on the Connecticut River. This design will include five murals depicting the history of flood control.

The pumping station will be a flat-roofed, brick and glass block structure 27' x 64.5' overall. The 12.5 inch thick brick walls, capped

with a cast stone coping, extend above the roof slab to form a parapet wall around the entire roof. A flat type roof was chosen as being economical and in keeping with the architectural design, as well as serving as a location for the engine exhaust mufflers. The roof system consists of steel beams encased in concrete and supported by steel columns. The roof slab will be 5-1/2 inches thick, covered with a cinder concrete fill sloped to drain. There are no outside pilasters. Inside the building there are pilasters at each structural steel column, the pilasters forming fireproof column encasements. The engine room floor will be a 7 and 10 inch structural concrete slab, with a monolithic finish. A hand operated traveling crane of 5 tons lifting capacity will operate for the full length of the building and will be used for installing and moving pumps and machinery. Access for the crane hoist to the pump room will be had through openings in the engine room floor, these openings being normally covered with removable checkered floor plates.

There is no window sash in the building. Light will be admitted through glass block panels, because of the exposed location of the pumping station near the river bank. The well diffused and uniform light which they provide and their appearance is also in keeping with the spirit of the architectural design. To provide ventilation, adjustable louvres have been placed low in the brick walls and a motor-operated exhaust has been placed on the roof. Two doors give access to the building. The main entrance door, 6 feet wide and 8'-9" high, consists of two leaves of hollow steel construction and give entrance directly to the engine room floor. It is large enough to provide adequate clearance for any replacement of mechanical equipment which may be required in the future. The small hollow steel door on the north end of the building provides a service passage.

VIII. CONSTRUCTION PROCEDURE

VIII. CONSTRUCTION PROCEDURE

A. Sequence of operations. - It is required in the specifications that the pumping station, intake structure, conduit, outlet structure, rack chamber, service bridge and all other features be completed in 220 calendar days after receipt by the contractor of notice to proceed. The specifications also require the contractor to complete certain portions of the work; namely, the conduit including impervious backfill, the outlet structure to elevation 15.0, the intake structure and all work necessary to permit diversion of the flow of water from the swale on or before September 15, 1941, in order to permit completion of the embankment before freezing weather sets in.

B. Construction period. - A study of hydrographs plotted from data recorded by the United States Weather Bureau from 1917 to 1940, a total of 24 consecutive years, shows that the majority of the floods at East Hartford occur in the spring months of March, April and May. The site of the pumping station is at Elevation 15.0 m.s.l., approximately and has been flooded at least once in almost every year recorded. It is noted, however, that between August 1 and March 8 the peak has reached Elevation 15.0 eleven times in the years tabulated below:

Date	Elevation of High Water
Dec. 17, 1920	18.2
Dec. 8, 1923	15.4
Feb. 14, 1925	15.7
Nov. 6, 1927	28.5
Dec. 10, 1927	17.5
Nov. 21, 1932	17.5
Jan. 12, 1935	20.2
Jan. 27, 1938	19.2
Sept. 23, 1938	34.9
Dec. 8, 1938	18.6
Dec. 12, 1938	17.9

Consideration of this matter, including a study of the above table, leads to the conclusion that if the work on the pumping station begins after August 1st, protection to Elevation 15.0 will probably be sufficient. It is planned to award the contract for the construction of the pumping station so that actual work may be started not later than August 1, 1941 and to have the whole contract completed not later than March 8, 1942. The contractor will be responsible for all damage by floods to Elevation 15.0 while the Government will be responsible for damage by floods exceeding that stage. It is anticipated that the work will be carried out in accordance with the following estimated construction schedule:

Designation	Quantity Cu.Yds.	Time Limits of Operation	No. of Days	Maximum Daily Rate of Construction cu. yd.
Conduit, including impervious backfill, outlet structure to El. 15.0 and Intake Structure		Aug. 1, 1941 to Sept. 15, 1941	45	
Delivery of Equipment		Oct. 1, 1941 Feb. 1, 1942		
Excavation for station		Aug. 1, 1941 Oct. 15, 1941		300
Concrete in station		Aug. 15, 1941 Jan. 1, 1942		100
Superstructure		Dec. 1, 1941 to Mar. 1, 1942		
Installation of mechanical equipment		Oct. 15, 1941 Mar. 1, 1941		
Job Completed		Mar. 8, 1942		

C. Closure of dike. - The completion of the embankment constructed under a separate contract will be accomplished by November 1, 1941. A

temporary bulkhead in the outlet structure is provided to protect the area from river floods. The construction may then be carried on with complete freedom from danger of flooding by the river. It is improbable that the construction site will become inundated by impounded rain water. The natural and artificial storage available should take care of all but exceptionally heavy storms.

D. Concrete construction.

1. Composition of concrete. - The concrete will be composed of cement, fine aggregate, coarse aggregate and water so proportioned and mixed as to produce a plastic, workable mixture. All concrete will be Class A except the pumping station base slab which will be Class B. Class A concrete will have an average compressive stress of not less than 3400 pounds per square inch in accordance with a standard 28-day test. The average compressive stress for Class B concrete will be 3000 pounds per square inch in accordance with a standard 28-day test. Concrete aggregates will be of suitable quality and will be tested by the Central Concrete Testing Laboratory of the North Atlantic Division at West Point.

2. Laboratory control. - A small concrete testing laboratory is available in the West Springfield Area of the district for use principally to control the quality of concrete during construction. The tests performed here will supplement those made at the Central Laboratory. Facilities will be available for testing the grading of aggregates, designing concrete mixtures, mixing of trial concrete batches for the purpose of developing actual relations between the compressive strength and the water cement ratio, and the casting of concrete cylinders for compressive strength tests.

a. Cement. - Portland cement of a well known and acceptable brand will be used throughout. The cement will be tested by the Central Laboratory and results of these tests shall be known before the cement is used.

b. Fine aggregate. - Natural sand will be used as a fine aggregate. The aggregate will be subject to thorough analysis, including magnesium sulphate soundness tests, and tests made on mortar specimens for compressive strength.

c. Coarse aggregate. - Washed gravel or crushed stone of required sizes will be used as coarse aggregate. It will consist of hard, tough and durable particles free from adherent coating and will be free from vegetable matter. Only a small amount of soft, friable, thin or elongated particles will be allowed. The aggregate will be subject to thorough analysis, accelerated freezing and thawing tests and to compressive tests in concrete cylinders.

d. Water. - The amount of water used per bag of cement for each batch of concrete will be predetermined; in general; it will be the minimum amount necessary to produce a plastic mixture of the strength specified. Slump tests will be required in accordance with the specifications.

3. Field Control.

a. Storage. - The cement will be stored in a thoroughly dry, weathertight and properly ventilated building. The fine and coarse aggregates will be stored in such a manner that inclusion of foreign material will be avoided.

b. Mixing. - The exact proportions of all ingredients of the concrete will be predetermined. The mixing will be done in approved mechanical mixers of a rotating type, and there will be adquate facilities for accurate measurement and control of each of the materials used in the concrete. Mixing will be done in batches of sizes as directed and samples will be taken for slump tests and for compressive strength tests. Inspectors will at all times supervise and inspect the mixing procedure.

c. Placing. - Concrete will be placed before the initial set has occurred. Forms will be clean, oiled, rigidly braced and of ample strength. Concrete poured directly against the ground will be placed on clean damp surfaces. Mechanical vibrators will be used and forking or hand spading will be applied adjacent to forms on exposed surfaces to insure smooth, even surfaces. The location of vertical and horizontal construction joints as well as contraction and expansion joints, and the location of copper water stops are indicated on the drawings. The locations of construction joints are tentative and may be changed to suit conditions in the field. Before placing concrete, all reinforcing steel will be inspected and pouring of the concrete will be supervised and directed by Government inspectors. Adequate precautions will be taken if concrete is to be placed in cold or hot weather.

E. Structural steel construction.

1. Superstructure framework. - The superstructure framework consists of beams and columns which will form a skeleton frame for the exterior walls and roof, and will provide a runway for the hand-operated crane. The columns will be securely anchored to the substructure concrete walls and will be connected to the roof beams with web connection

angles and wind bracing connections. The crane rails will be fastened to the crane runway beams with bent hook bolts. Crane stops at each end of the runway will prevent the traveling crane from running into the end walls.

2. Stairways. - The stairways consist of open grating treads fastened to structural steel stairway channels with wrought iron pipe railings fastened to the top flanges of the channels.

3. Trash racks. - The trash racks are made up of structural channel frames which support 4" x 3/8" grating bars spaced 2-5/8" in the clear. The racks are welded throughout.

4. Removable floor plates. - Access for the crane to pump room will be obtained by removing checkered floor plates which cover the opening in the engine room floor. The removable covers consist of 1/4-inch checkered plates welded to the 2-1/2" leg of 3" x 2-1/2" x 5/16" angles. The ends are supported on angle frames anchored into the floor concrete. Each opening in the floor is covered with two sections. Lifting handles are provided in the plates for easy removal.

5. Miscellaneous angles and frames. - Miscellaneous structural steel such as door frames, angles, grilles, etc., will be erected and placed as indicated on the drawings and at such time as required.

IX. SUMMARY OF COST

IX. SUMMARY OF COST

The total construction cost of the Meadow Hill pumping station, including the conduit, intake and outlet structures, access road and mechanical equipment has been estimated to be $247,000 including 10% for contingencies and 15% for engineering.

This amount has been distributed as follows:

(1)	Pumping station. -		
	a. Concrete features	$39,000	
	b. Superstructure	32,000	
	c. Miscellaneous	27,000	
			$98,000
(2)	Conduit. -		
	a. Concrete details.	$28,400	
	b. Miscellaneous	13,600	
			42,000
(3)	Mechanical equipment		107,000
	TOTAL		$247,000

(1) a. The concrete features included under the pumping station item (1) a. consist of intake structure, rack chamber at sanitary interceptor and building foundation to and including operating floor structural slab.

(1) b. The superstructure consists of the complete building above the operating floor.

(1) c. Miscellaneous items are common excavation and backfill, miscellaneous iron and steel, trash racks, seeding, gravel for roads,

bituminous road surfacing and other items not included in (1) a. and (1) b.

(2) a. The concrete features included under the conduit item (2) a. consist of the conduit at the pumping station, the conduit with seep rings under the dike, the service bridge piers and concrete steps and the outlet structure.

(2) b. Miscellaneous items are common excavation and backfill, riprap, miscellaneous iron and steel and service bridge superstructure.

(3) The mechanical equipment consists of pumps, gas engines, gear units, crane, generating units, valves and piping, sluice gate system, and miscellaneous items.

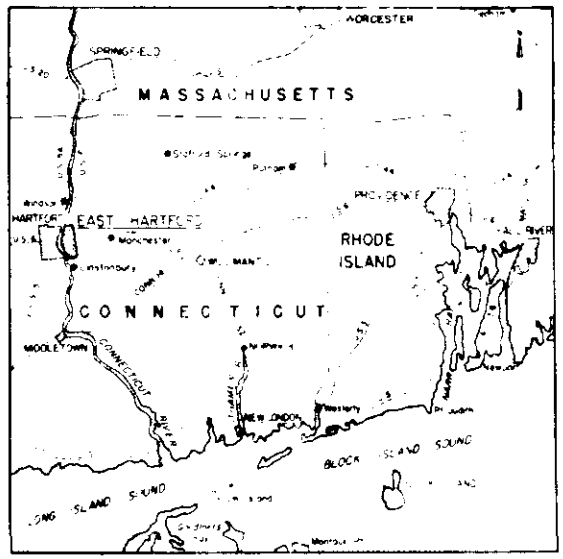
Prices used are estimated prices except for the pumps, gear units, gas engines and motor which are actual bid prices for this job.

PLATES

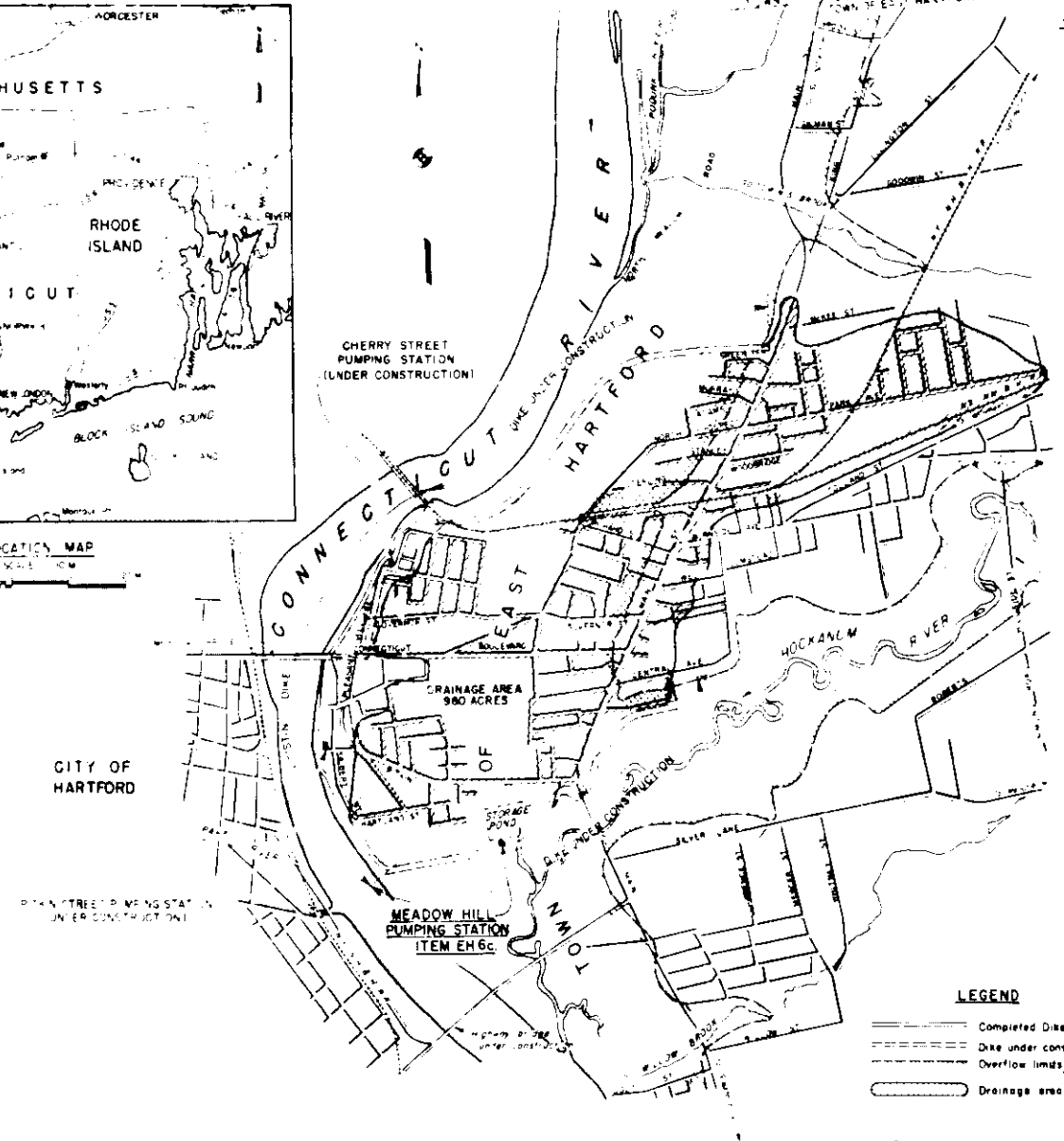
INDEX FOR PLATES

Plate	
1	Project location and index
2	Hydrograph No. 1
3	Hydrograph No. 2
4	Storm sewer map
5	Sanitary sewer map
6	Rainfall intensity - Frequency curves
7	Stage - Frequency Curves
8	Stage - Duration Curve
9	Storm run-off analysis
10	Hydrology study
11	Required pump capacity
12	Pumping capacity
13	Hydraulic elements of gravity flow conduit
14	Hydraulic characteristics of gravity flow conduit
15	Subsurface explorations and borrow area
16	Plan and geologic section
17	Providence District soils classification
18	Consolidation characteristics
19	Consolidation characteristics
20	General plan
21	Detail plan
22	Conduit details
23	Engine room floor plan - Architectural
24	Roof plan and details - Architectural

Plate	
25	Sections - Architectural
26	General arrangement of equipment No. 1
27	General arrangement of equipment No. 2
28	General Arrangement of equipment No. 3
29	Pumping station perspective
30	Organization chart



LOCATION MAP



VICINITY MAP

INDEX TO DRAWINGS

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1	PROJECT LOCATION AND INDEX	CT-4-2975
2	GENERAL PLAN	CT-4-2976
3	STAGE HYDROGRAPH NO. 1	CT-4-208
4	STAGE HYDROGRAPH NO. 2	CT-3-209
5	SUBSURFACE EXPLORATIONS AND BORROW AREA	CT-2-328
6	DETAIL PLAN	CT-4-2977
7	INTAKE STRUCTURE DETAILS NO. 1	CT-4-2978
8	INTAKE STRUCTURE DETAILS NO. 2	CT-4-2979
9	CONDUIT DETAILS	CT-4-298[illegible]
10	DETAILS OF CONDUIT AND RACK CHAMBER	CT-4-298[illegible]
11	SERVICE BRIDGE PIERS	CT-4-298[illegible]
12	OUTLET STRUCTURE DETAILS	CT-4-2983
13	MISCELLANEOUS DETAILS	CT-4-2984
14	ENGINE ROOM FLOOR PLAN - ARCHITECTURAL	CT-4-2985
15	ROOF PLAN AND DETAILS - ARCHITECTURAL	CT-4-2986
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17	ELEVATIONS - ARCHITECTURAL	CT-4-2988
18	SECTIONS - ARCHITECTURAL	CT-4-2989
19	MAIN ENTRANCE AND DETAILS - ARCHITECTURAL	CT-4-2990
20	MISCELLANEOUS DETAILS - ARCHITECTURAL	CT-4-299[illegible]
21	CAST STONE DETAILS - ARCHITECTURAL	CT-4-2992
22	STRUCTURAL STEEL FRAMING	CT-4-2993
23	STRUCTURAL STEEL DETAILS	CT-4-2994
24	ROOF SLAB STEEL REINFORCEMENT NO. 1	CT-4-2995
25	ROOF SLAB STEEL REINFORCEMENT NO. 2	CT-4-2996
26	ENGINE ROOM FLOOR SLAB STEEL REINFORCEMENT NO. 1	CT-4-2997
27	ENGINE ROOM FLOOR SLAB STEEL REINFORCEMENT NO. 2	CT-4-2998
28	ENGINE ROOM FLOOR SLAB STEEL REINFORCEMENT NO. 3	CT-4-2999
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42	INTAKE STRUCTURE - STEEL REINFORCEMENT NO. 3	CT-4-3013
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49	MISCELLANEOUS STEEL DETAILS NO. 1	CT-4-3020
50	MISCELLANEOUS STEEL DETAILS NO. 2	CT-4-3021
51	MISCELLANEOUS STEEL DETAILS NO. 3	CT-4-3022
52	MISCELLANEOUS STEEL DETAILS NO. 4	CT-4-3023
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55	GENERAL ARRANGEMENT OF EQUIPMENT NO. 1	CT-4-3026
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61	GASOLINE PIPING NO. 1	CT-4-3032
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63	SLUICE GATES	CT-4-3034
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66	ELECTRIC LIGHT AND POWER SYSTEM NO. 2	CT-4-3037
67	ELECTRIC LIGHT AND POWER SYSTEM NO. 3	CT-4-3038

LEGEND

- Completed Dike
- Dike under construction
- Overflow limits, March 1936 flood
- Drainage area

CONNECTICUT RIVER FLOOD CONTROL

MEADOW HILL PUMPING STATION

EAST HARTFORD, CONN.

PROJECT LOCATION AND INDEX

CONNECTICUT RIVER — CONNECTICUT

67 SHEETS — SCALE: 1 INCH = 100 FT — SHEET NO. 1

U.S. ENGINEER OFFICE, PROVIDENCE, R.I. — JUNE 941

FILE NO. CT-4-2975

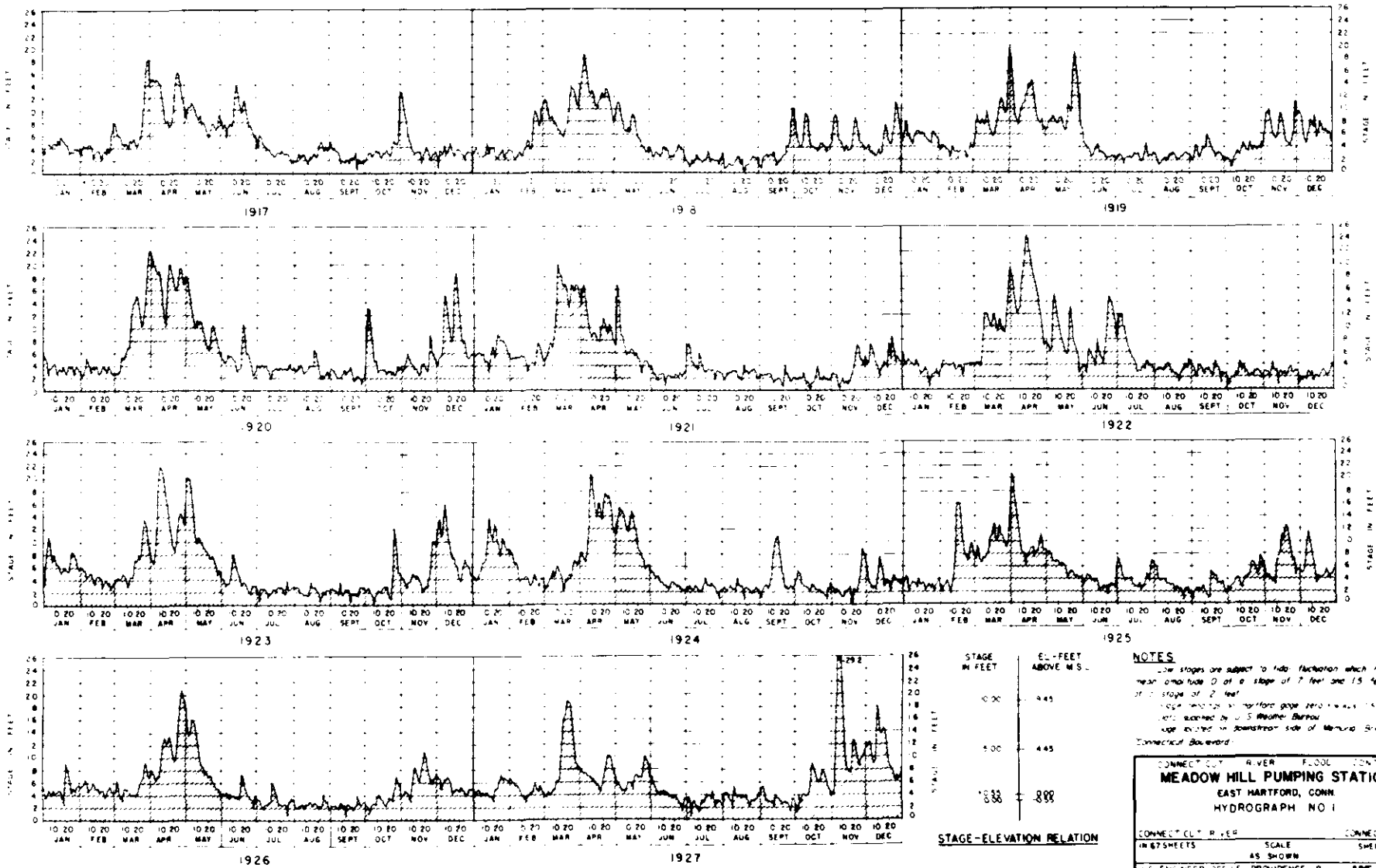
REV.	DATE	REASON

EH 6c

PLATE NO. 1

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



STAGE IN FEET	EL.-FEET ABOVE M.S.L.
10.00	9.45
5.00	4.45
0.55	0.00
0.00	-0.55

STAGE-ELEVATION RELATION

NOTES

Low stages are subject to tidal fluctuation which has a mean amplitude 0 at a stage of 7 feet and 1.5 feet at a stage of 2 feet.

Stage readings on Hartford gage zero [illegible]

Data supplied by U.S. Weather Bureau

Gage located on downstream side of Memorial Bridge Connecticut Boulevard

CONNECTICUT RIVER FLOOD CONTROL

MEADOW HILL PUMPING STATION

EAST HARTFORD, CONN.

HYDROGRAPH NO. 1

CONNECTICUT RIVER — CONNECTICUT

IN 67 SHEETS — SCALE AS SHOWN — SHEET NO. 3

U.S. ENGINEER OFFICE, PROVIDENCE, R.I. — JUNE 1941

FISCAL YEAR 194

FILE NO. CT-3-1208

KEY	DATE	REVISION indicated by Δ	REV BY	CK BY	AP BY

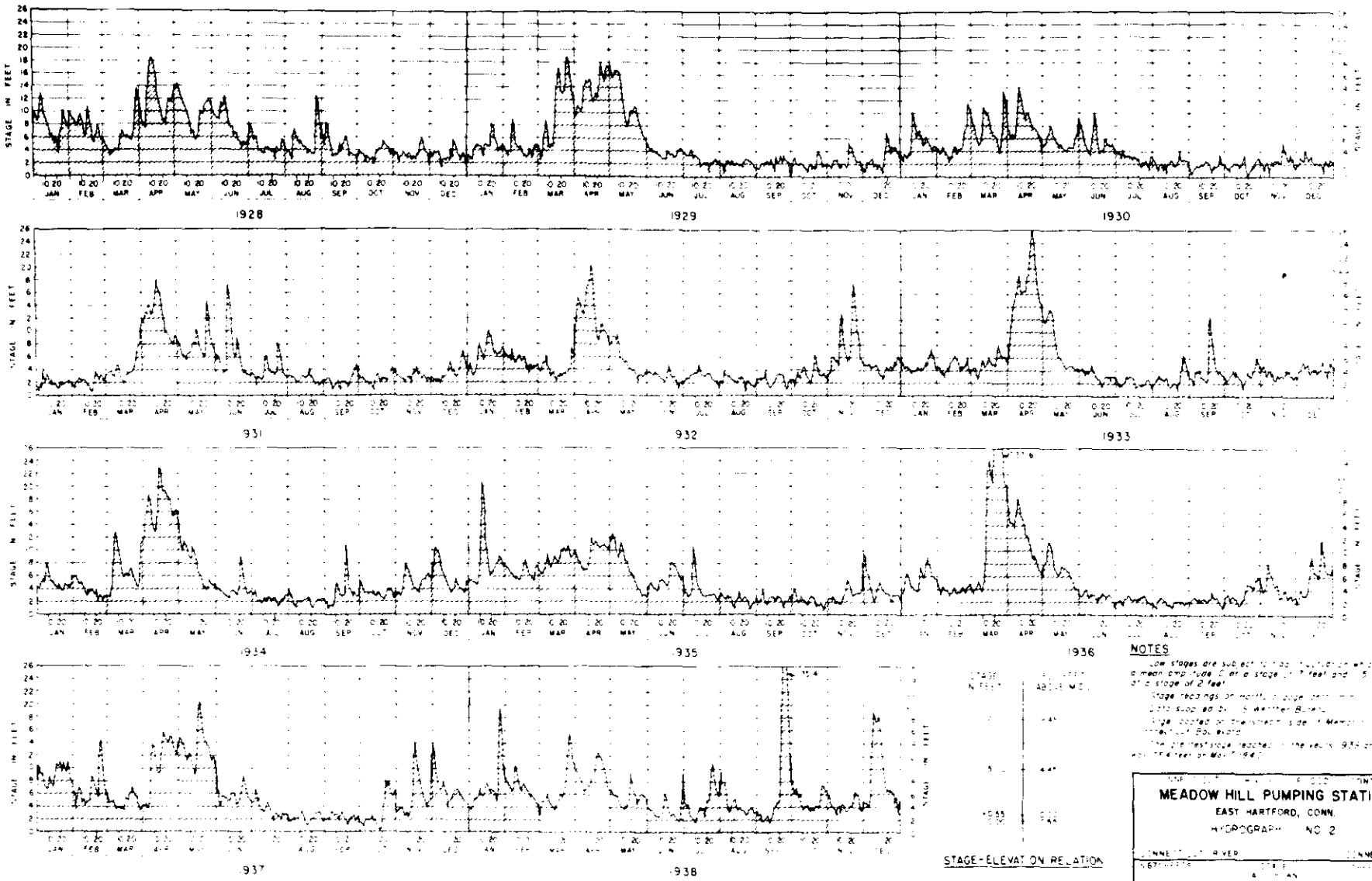
PLATE NO. 2

EH 6c

3

WAR DEPARTMENT

CORPS OF ENGINEERS, U S ARMY



STAGE-ELEVATION RELATION

NOTES

Low stages are subject to [illegible] a mean amplitude [illegible] at a stage of 7 feet and [illegible] feet at a stage of 2 feet

Stage readings on [illegible]

Data supplied by [illegible] Weather Bureau

Stage located on the [illegible] side of Memorial Bridge [illegible] Boulevard

The greatest stage reached in the years 1938 and 1940 was 15.4 feet on May 7, 1940

MEADOW HILL PUMPING STATION

EAST HARTFORD, CONN.

HYDROGRAPH NO. 2

CONNECTICUT RIVER

ENGINEER OFFICE

JUNE 1940

FILE NO. [illegible]

EH 6c

PLATE NO. 3

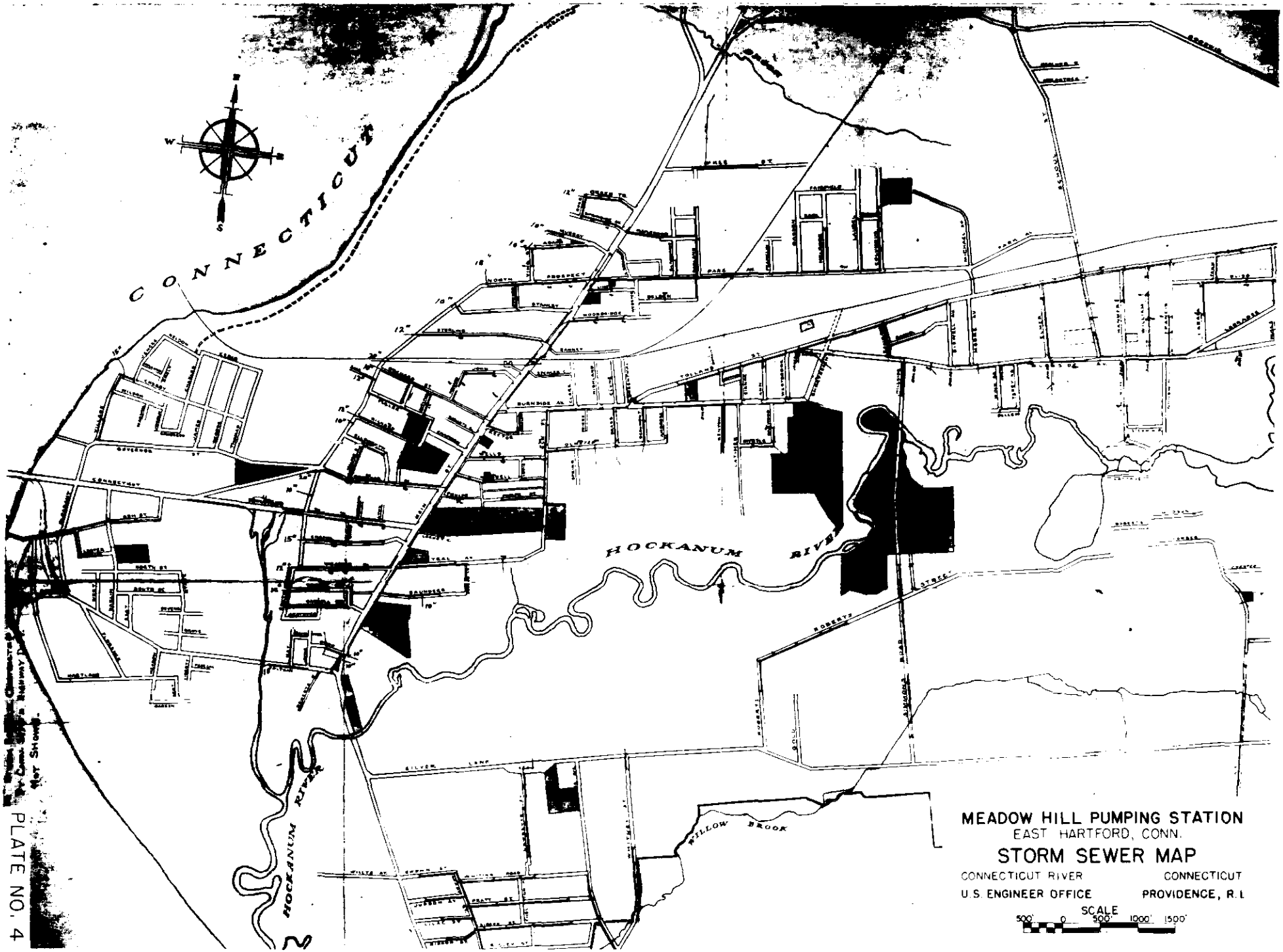

CONNECTICUT
HOCKANUM RIVER
HOCKANUM RIVER
WILLOW BROOK
MEADOW HILL PUMPING STATION
EAST HARTFORD, CONN.
STORM SEWER MAP
CONNECTICUT RIVER
CONNECTICUT
U.S. ENGINEER OFFICE
PROVIDENCE, R.I.
SCALE
500' 0 500' 1000' 1500'

PLATE NO. 4

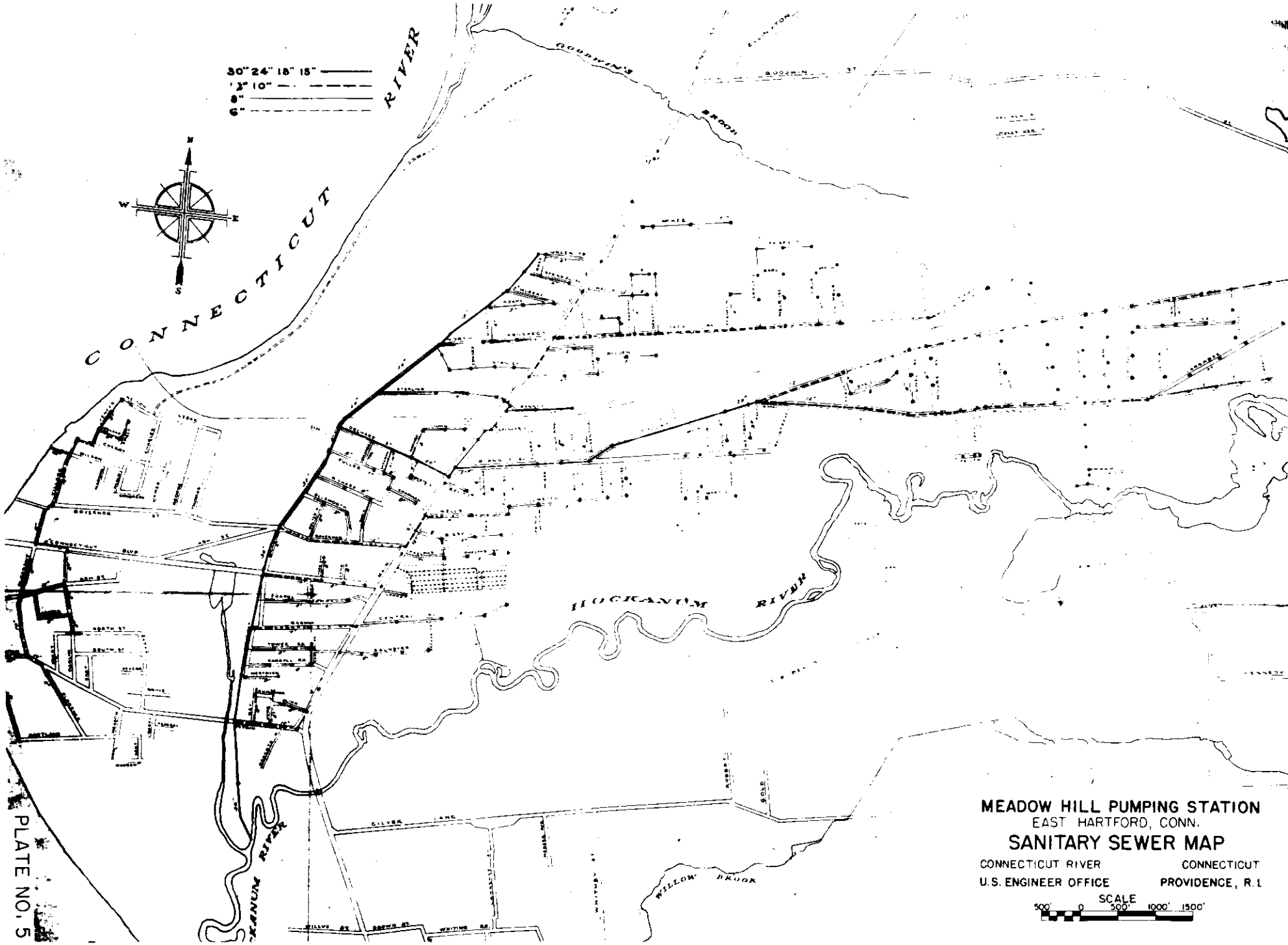
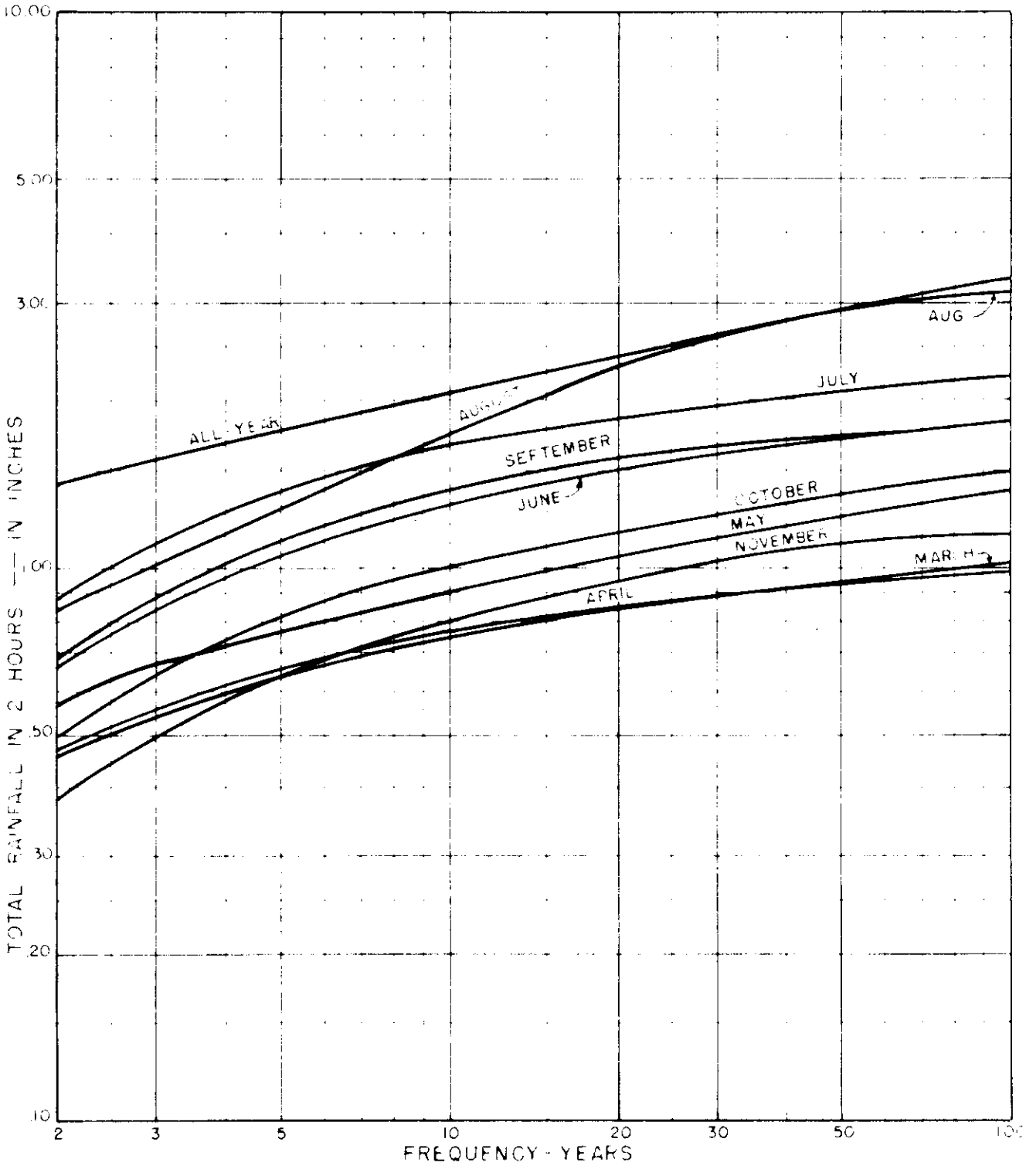

30" 24" 18" 15"
12" 10"
8"
6"
CONNECTICUT RIVER
GOODWIN'S BROOK
HOCKANUM RIVER
WILLOW BROOK
N
S
E
W
MEADOW HILL PUMPING STATION
EAST HARTFORD, CONN.
SANITARY SEWER MAP
CONNECTICUT RIVER
CONNECTICUT
U.S. ENGINEER OFFICE
PROVIDENCE, R.I.
SCALE
500' 0 500' 1000' 1500'

PLATE NO. 5



CONNECTICUT RIVER FLOOD CONTROL

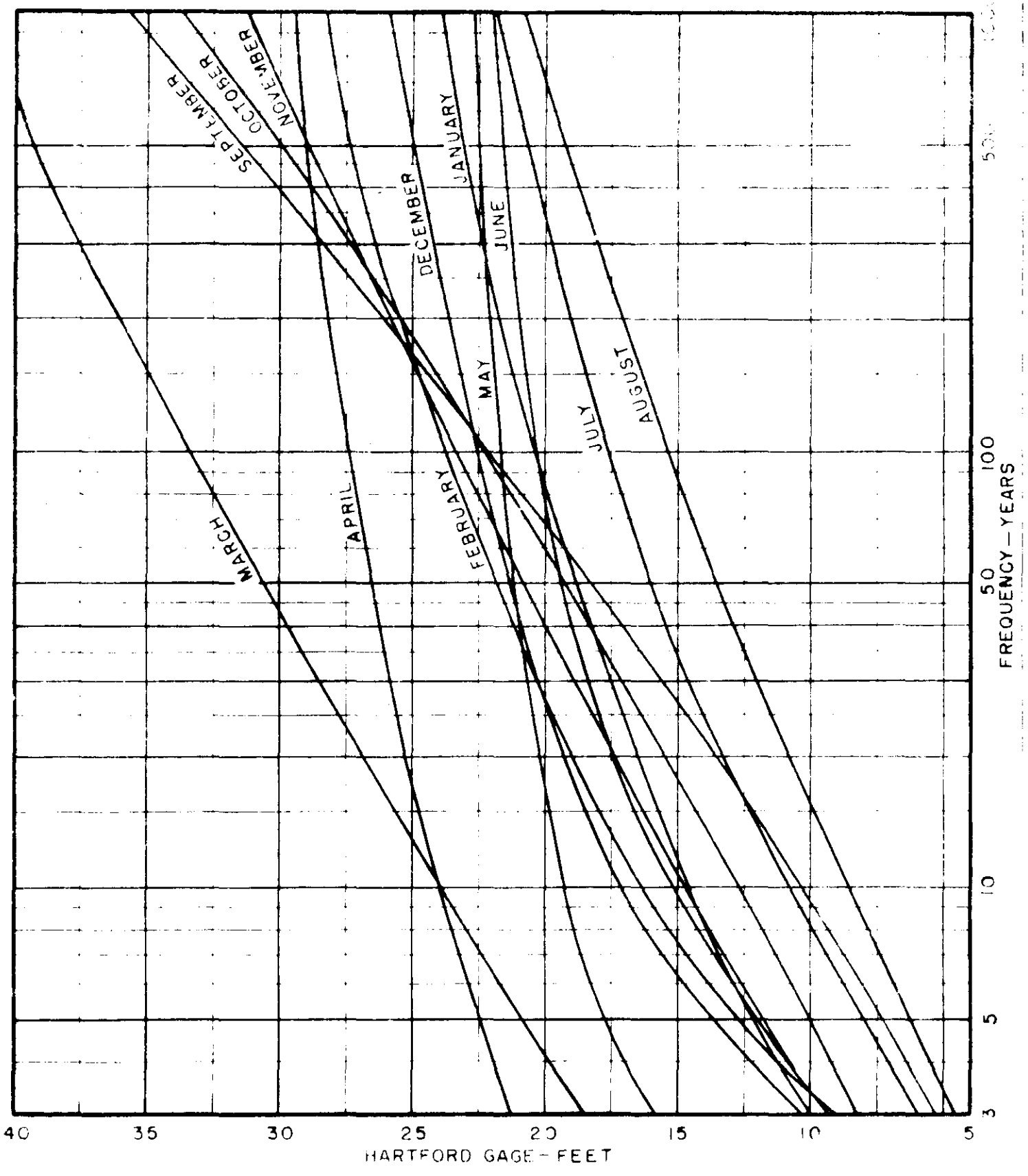
RAINFALL INTENSITY - FREQUENCY CURVES

2 - HOUR STORM

HARTFORD, CONNECTICUT

35 YEARS OF RECORD - 1905 TO 1939 INCL

PLATE NO 6



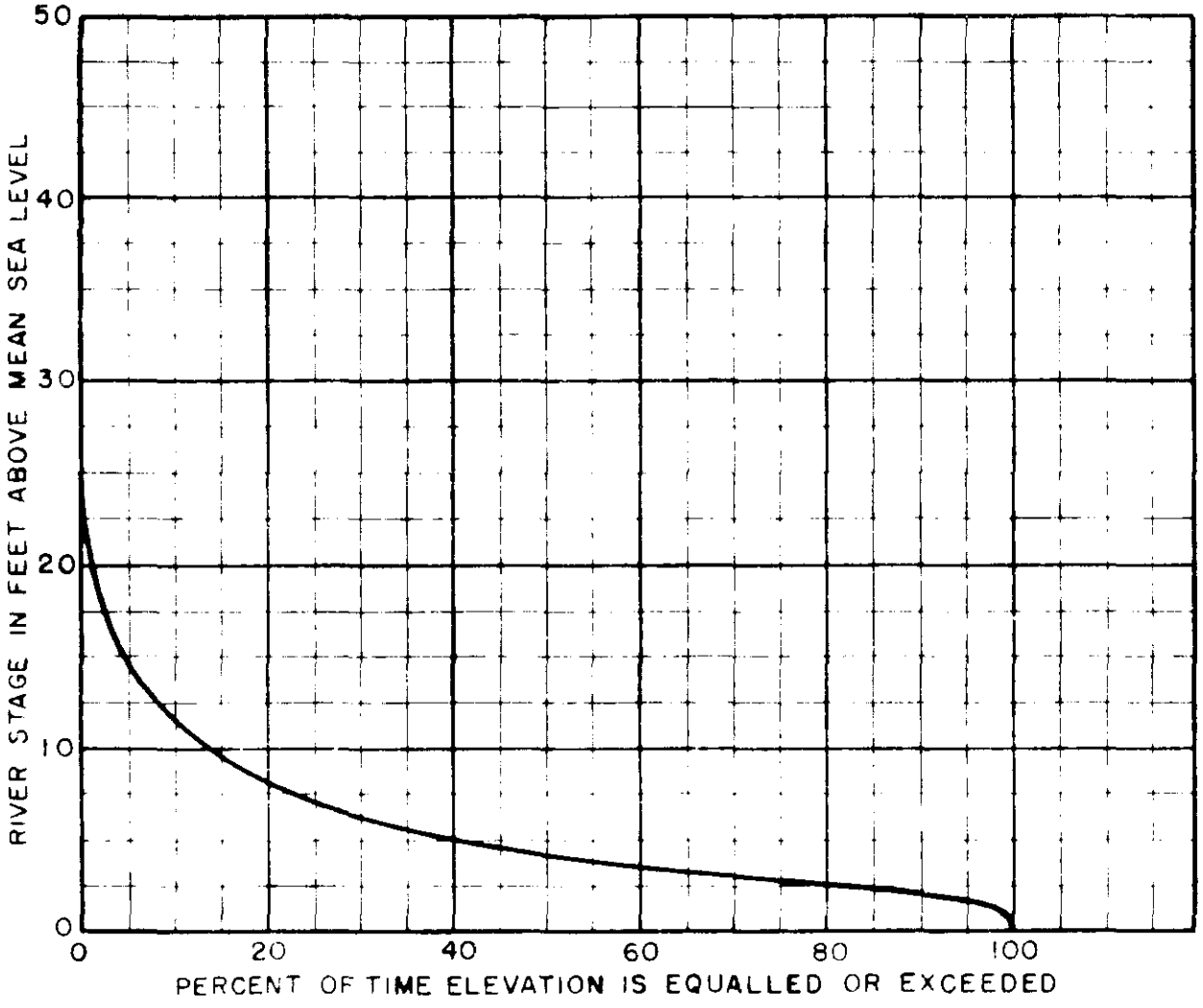
CONNECTICUT RIVER

STAGE — FREQUENCY CURVES

EAST HARTFORD, CONNECTICUT

ZERO HARTFORD GAGE = MINUS 0.55 M.S.L.

PLATE NO. 7

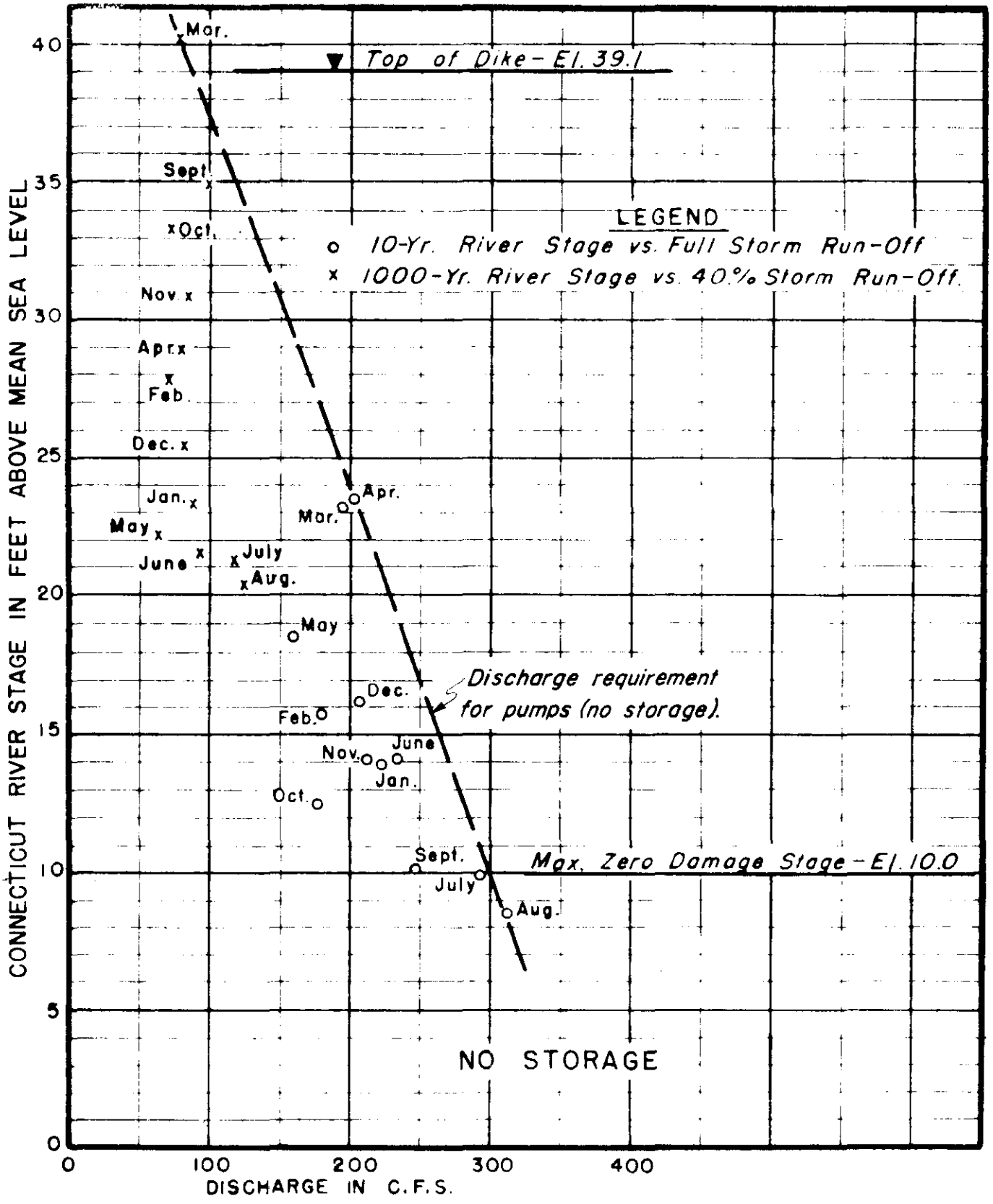


CONNECTICUT RIVER

STAGE—DURATION CURVE

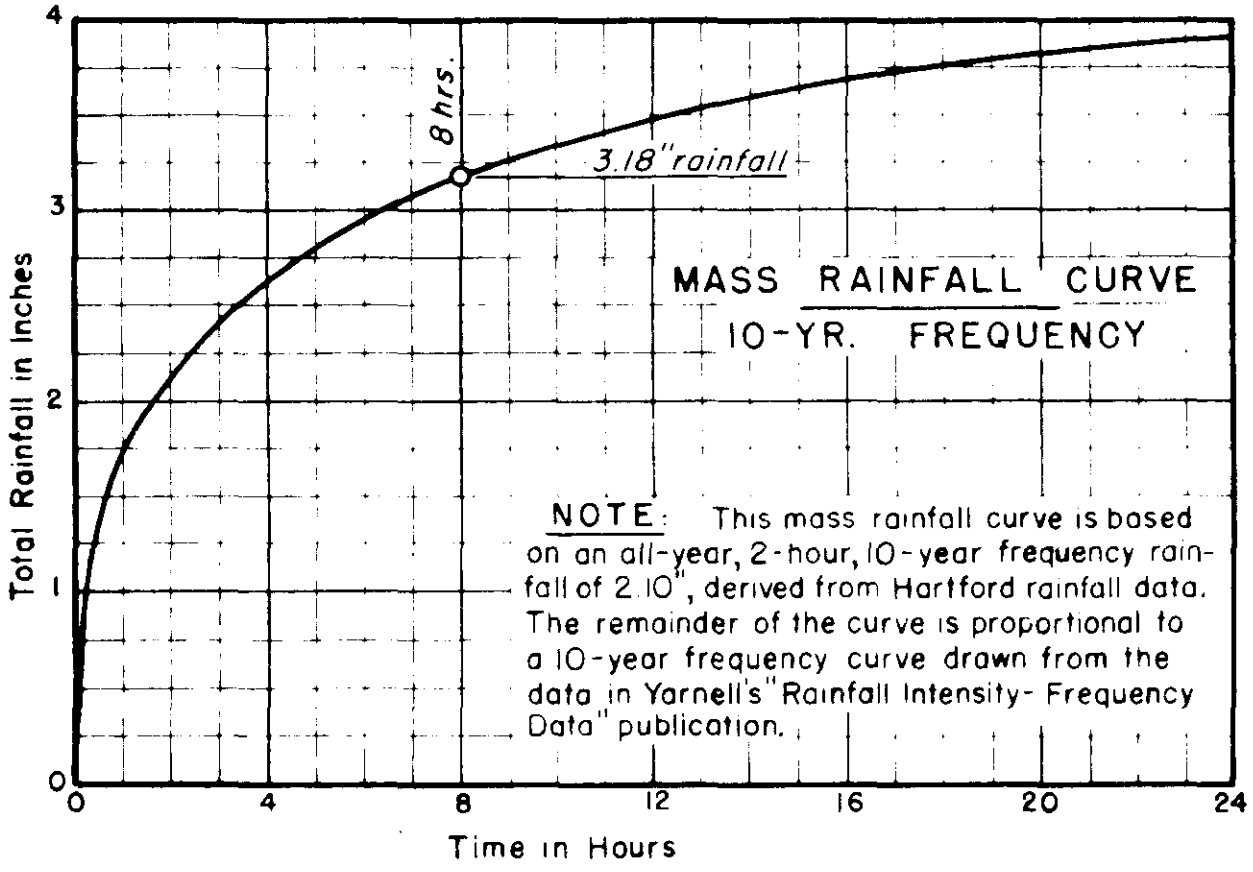
AT

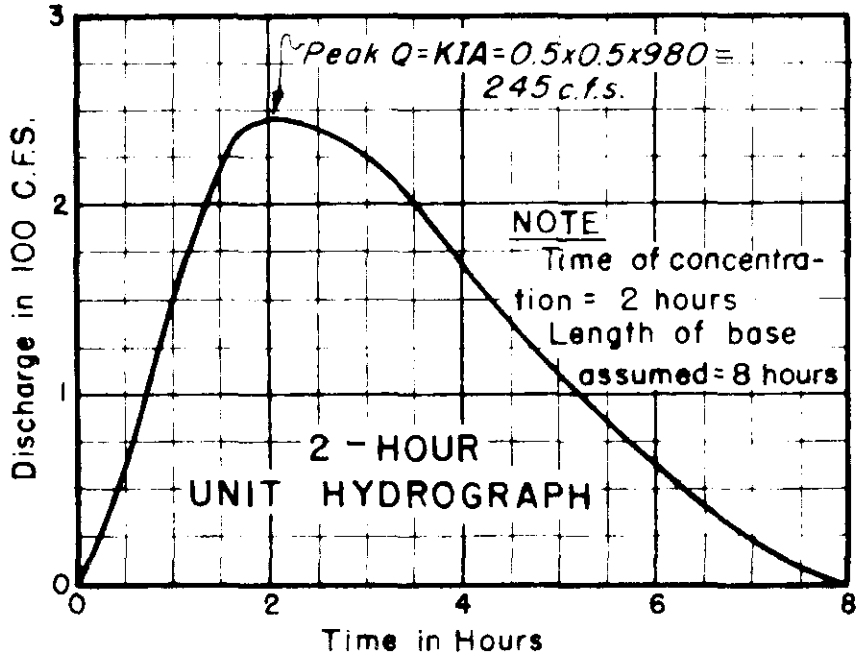
EAST HARTFORD



EAST HARTFORD DIKE
MEADOW HILL PUMPING STATION
STORM RUN-OFF
ANALYSIS

PLATE NO. 9





BASIC DATA

Drainage area = 980 acres

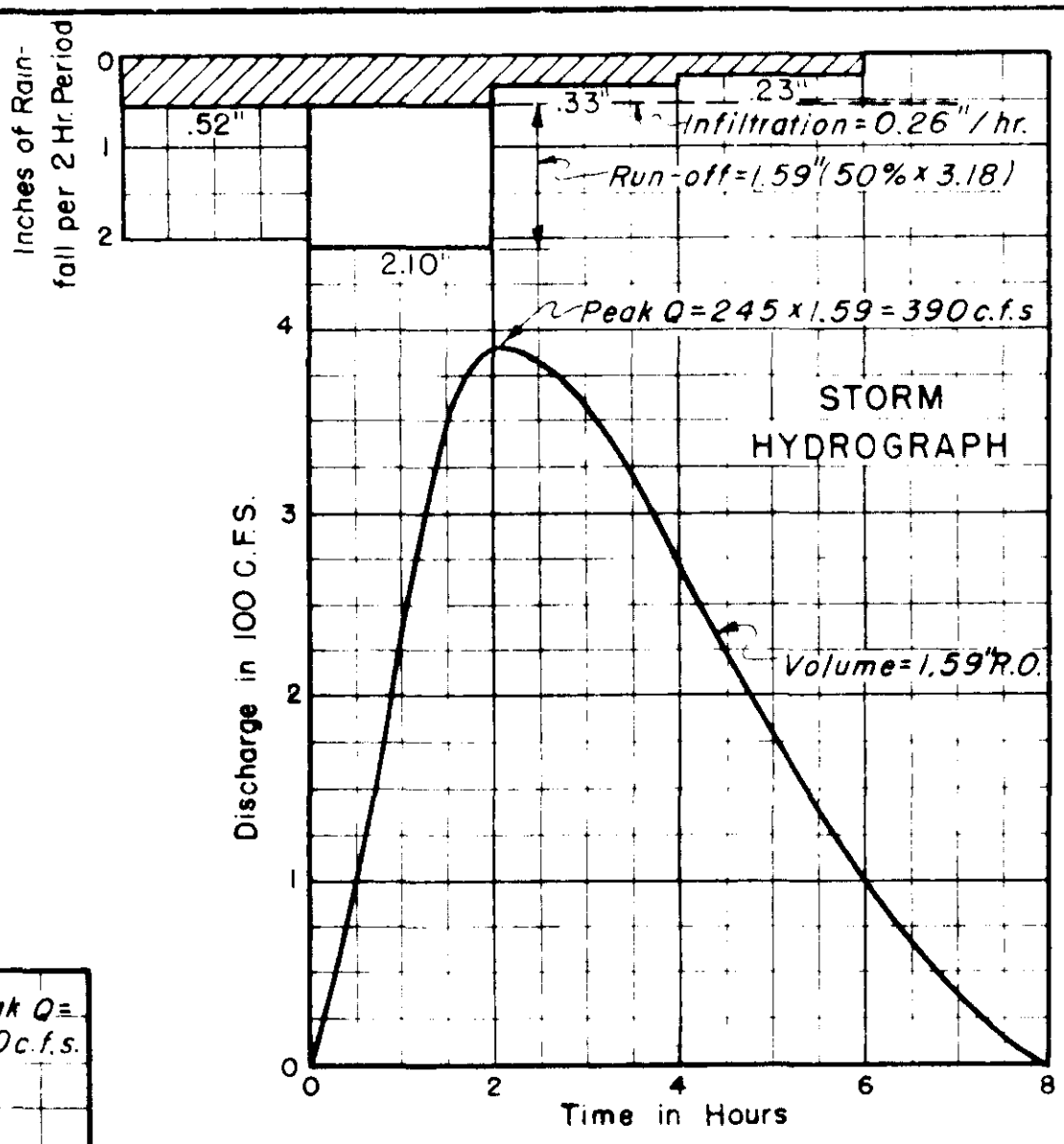
EAST HARTFORD DIKE

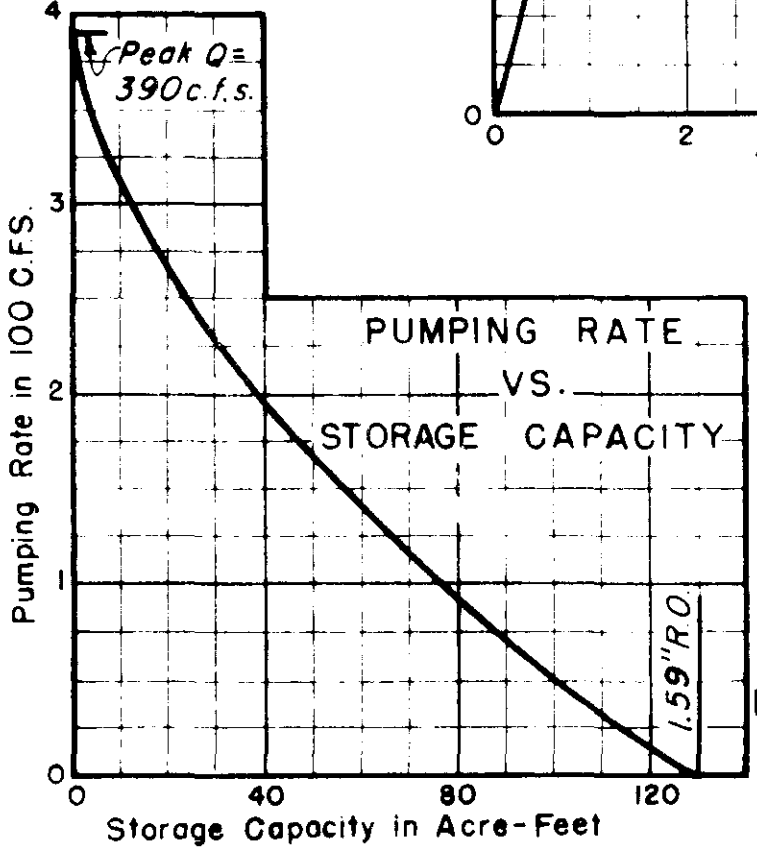
MEADOW HILL PUMPING STATION

HYDROLOGY STUDY

TO DETERMINE

PUMPING REQUIREMENTS





EAST HARTFORD DIKE

MEADOW HILL PUMPING STATION

STORM HYDROGRAPH

AND

REQUIRED PUMP CAPACITY

PLATE NO. 11

MEADOW HILL PUMPING STATION

PUMPING CAPACITY

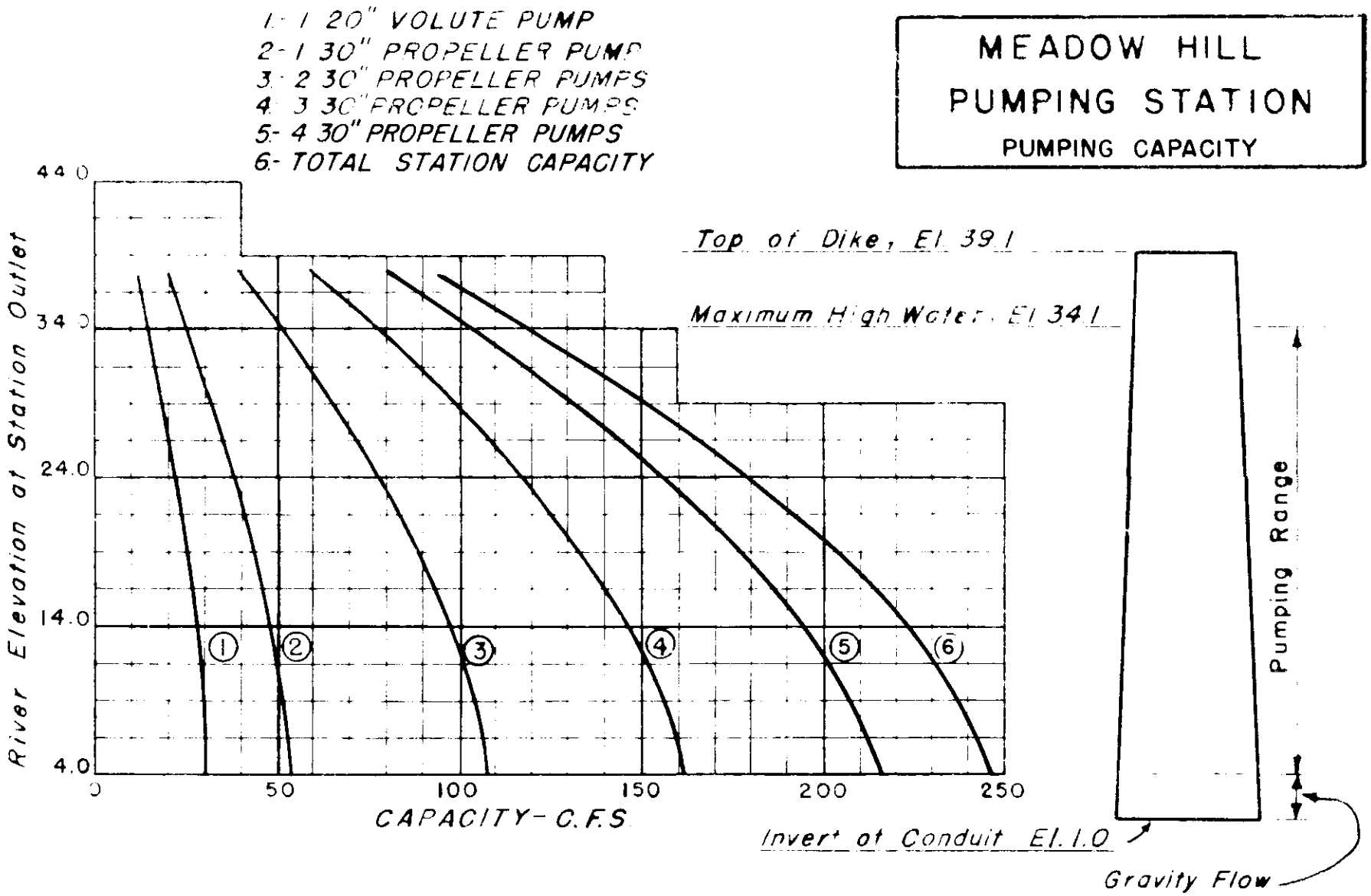


PLATE NO. 12

$Q_n = \frac{1.486}{n} AR^{2/3} S^{1/2}$ NORMAL FLOW FORMULA

$Q_{cr} = 5.67 A\sqrt{d}$ CRITICAL FLOW FORMULA

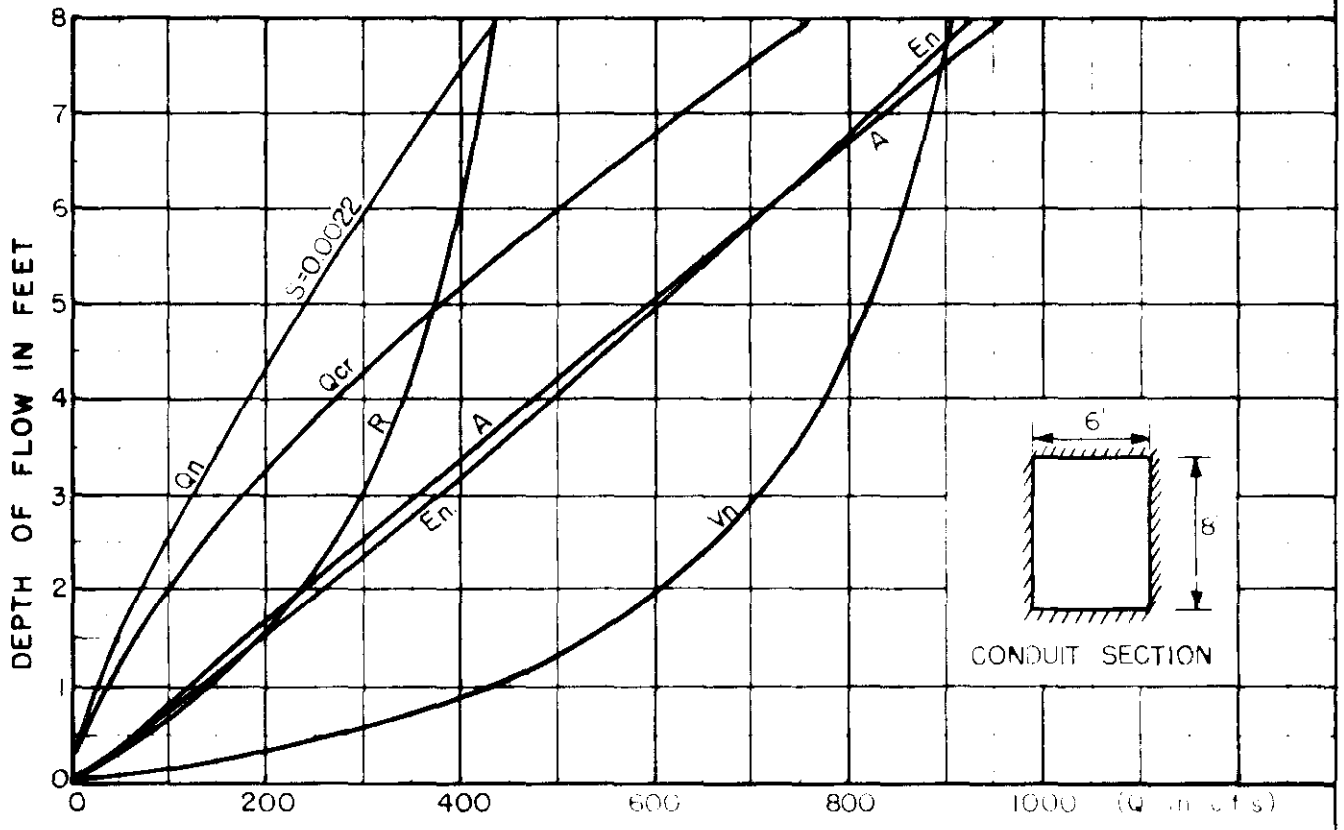
Q = DISCHARGE

A = AREA

R = HYDRAULIC RADIUS

E = ENERGY

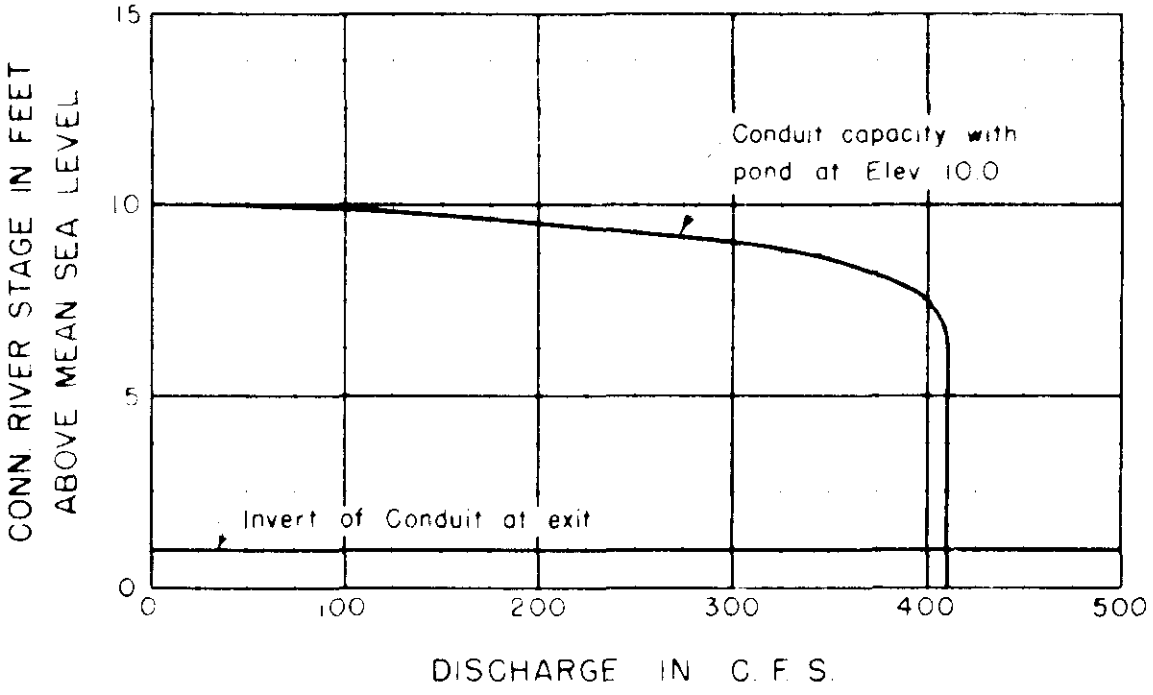
V = VELOCITY

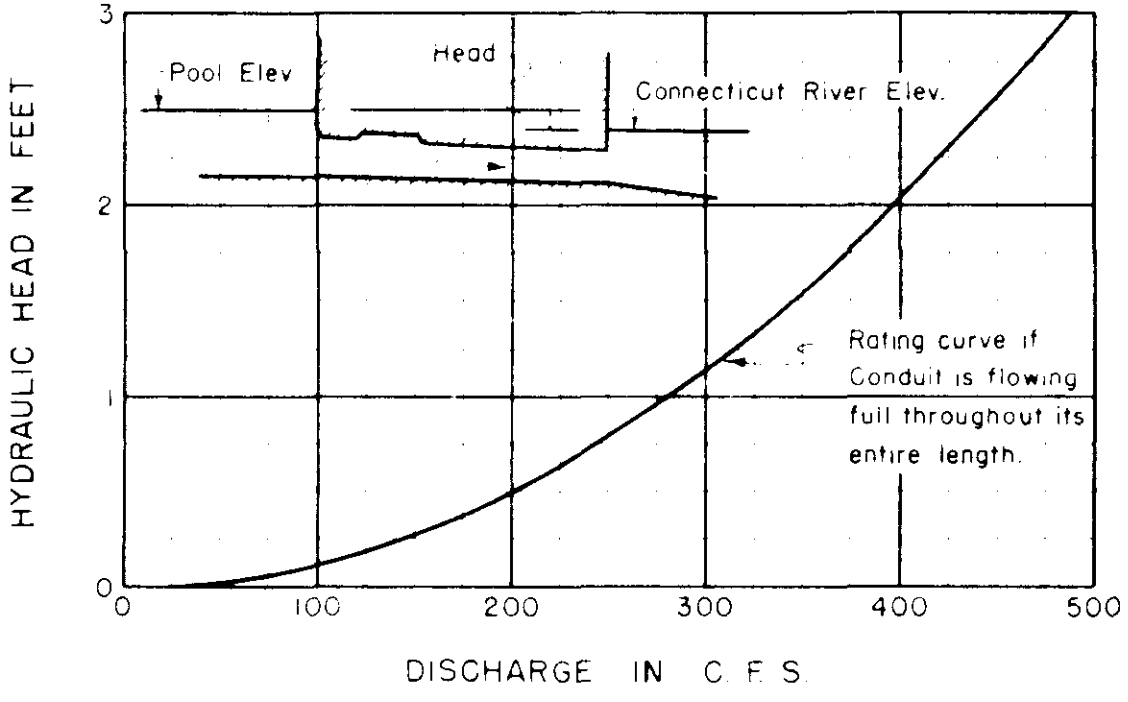


0	200	400	600	800	1000	(Q in c.f.s.)
0	10	20	30	40	50	(A in sq. ft)
0	1	2	3	4	5	(R in ft.)
0	2	4	6	8	10	(V in ft/sec.)
0	2	4	6	8	10	(E in ft.)

MEADOW HILL PUMPING STATION

HYDRAULIC ELEMENTS OF GRAVITY FLOW CONDUIT





MEADOW HILL PUMPING STATION
HYDRAULIC CHARACTERISTICS
OF
GRAVITY FLOW CONDUIT

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

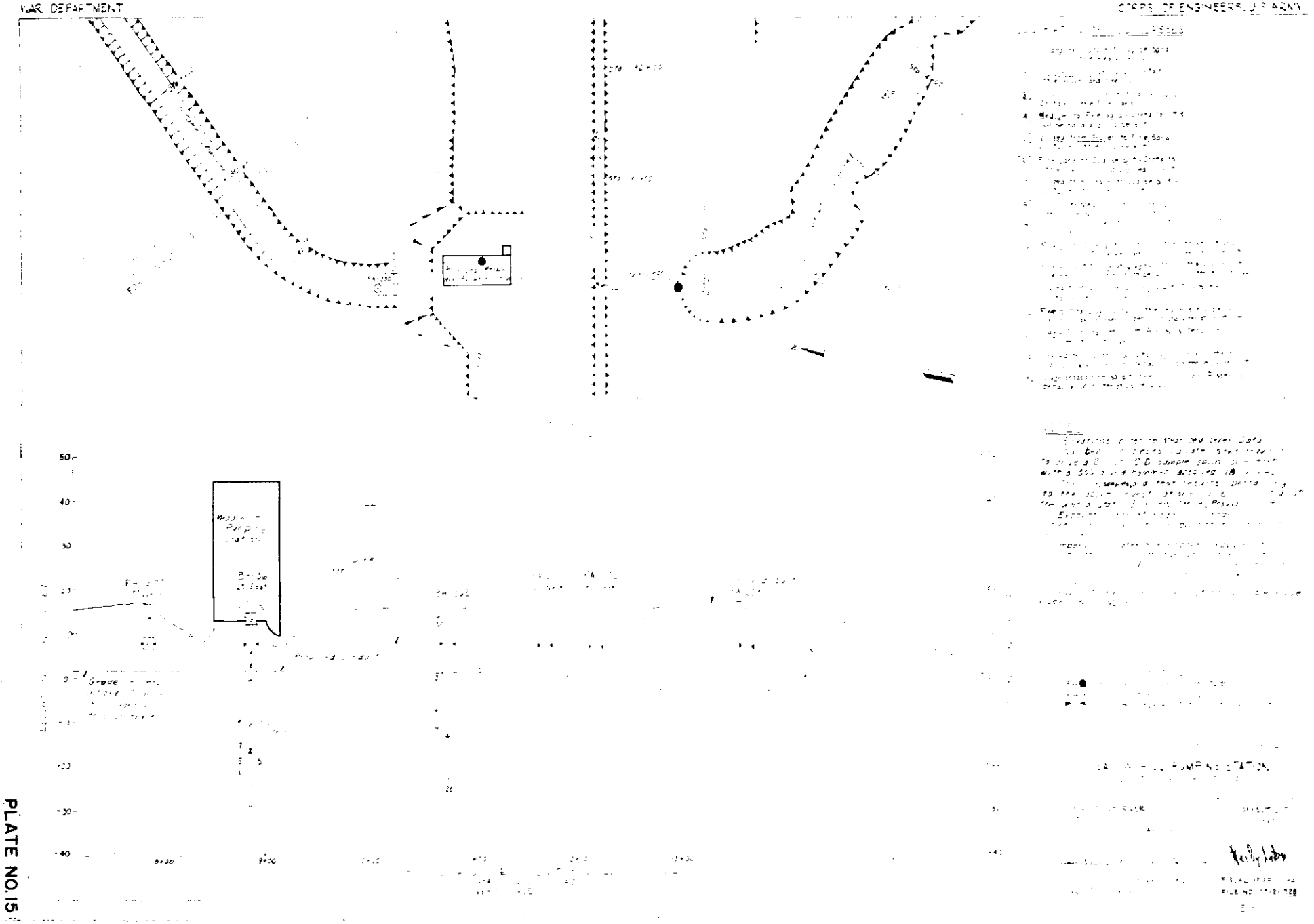
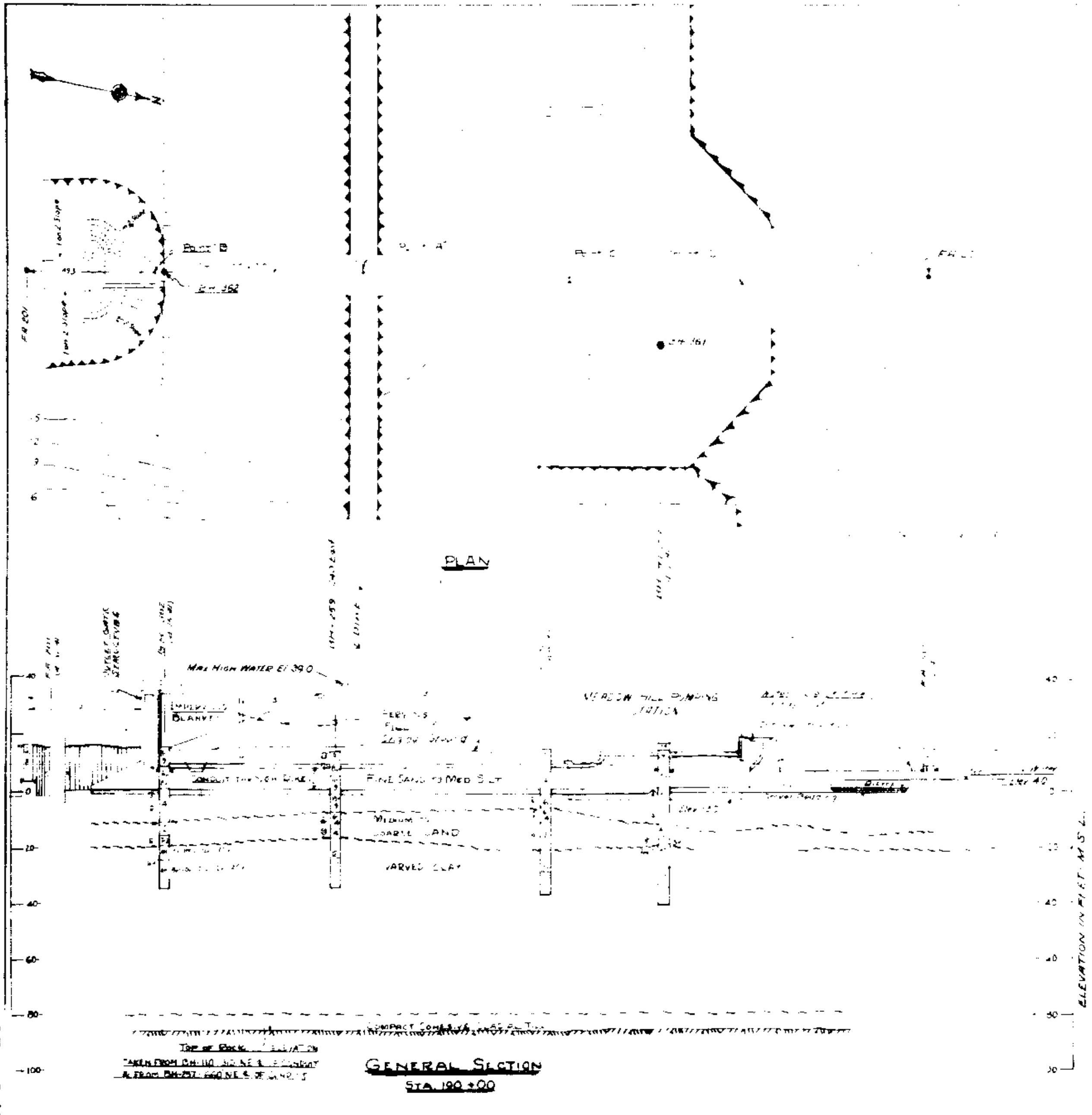


PLATE NO. 15



Average Properties of Foundation Material

Overburden Load Excavation Release

Total Overburden Release 345#/sq ft

Station Dead Load

Net Load on Foundation 156#/sq ft

Actual Load = 563#/sq ft − 345#/sq ft = 219#/sq ft

LEGEND

NOTE

CONNECTICUT RIVER FLOOD CONTROL
MEADOW HILL PUMPING STATION
EAST HARTFORD CONN
PLAN & GEOLOGIC SECTION

ENGINEERING DIVISION	SOILS LABORATORY
U. S. ENGINEER OFFICE	PROVIDENCE R. I.
SUBMITTED BY	DATE MAY 15 1941
ANALYSIS BY	SCALE 1" = 20' VERT. & HOR.
DRAWN BY	
TRACED BY	S.L. NO. EH-8C-D14

PLATE NO. 16

PROVIDENCE DISTRICT SOIL CLASSIFICATION

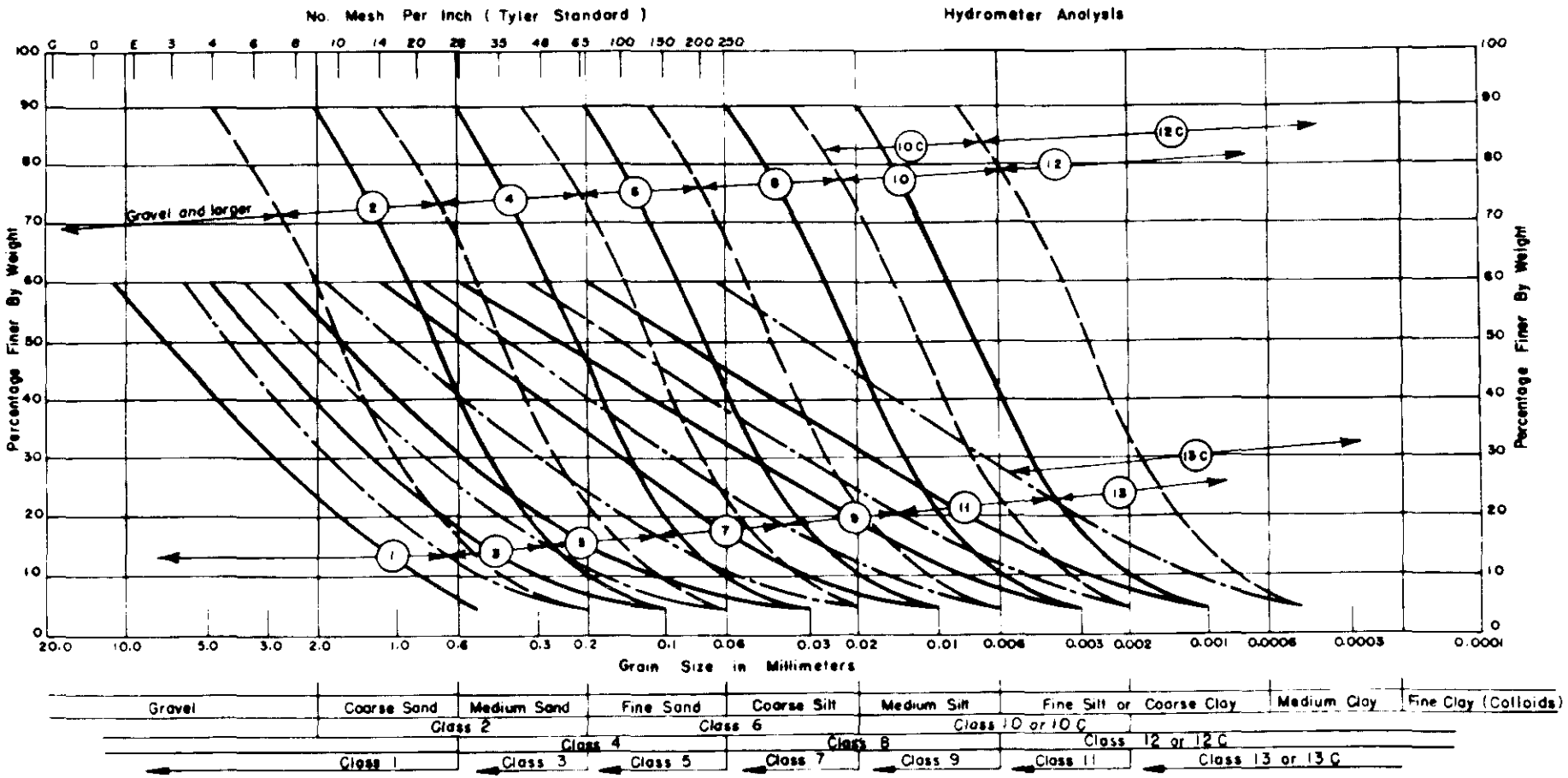
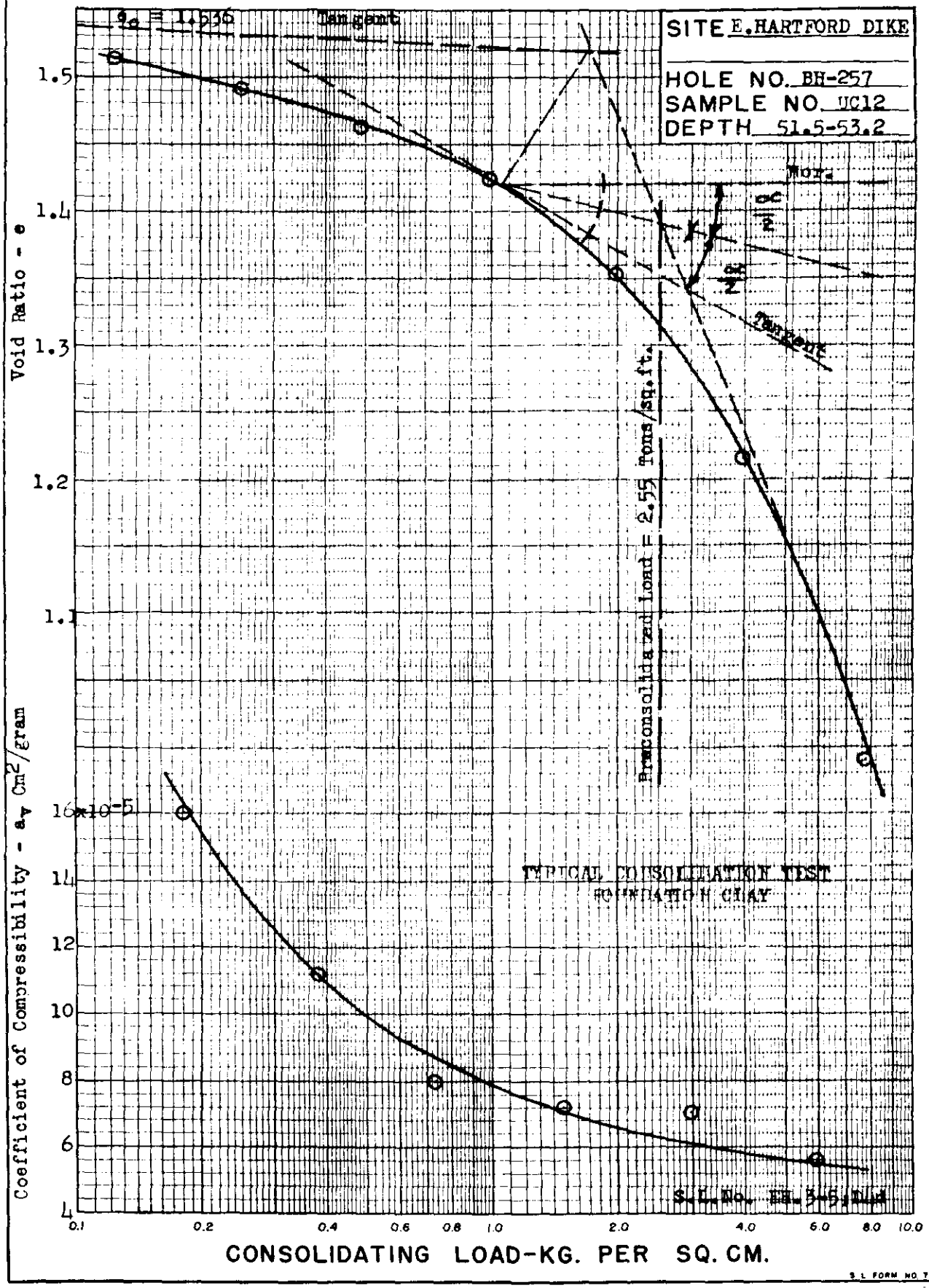


DIAGRAM SHOWING LIMITS OF SOIL CLASSES

PLATE NO. 17

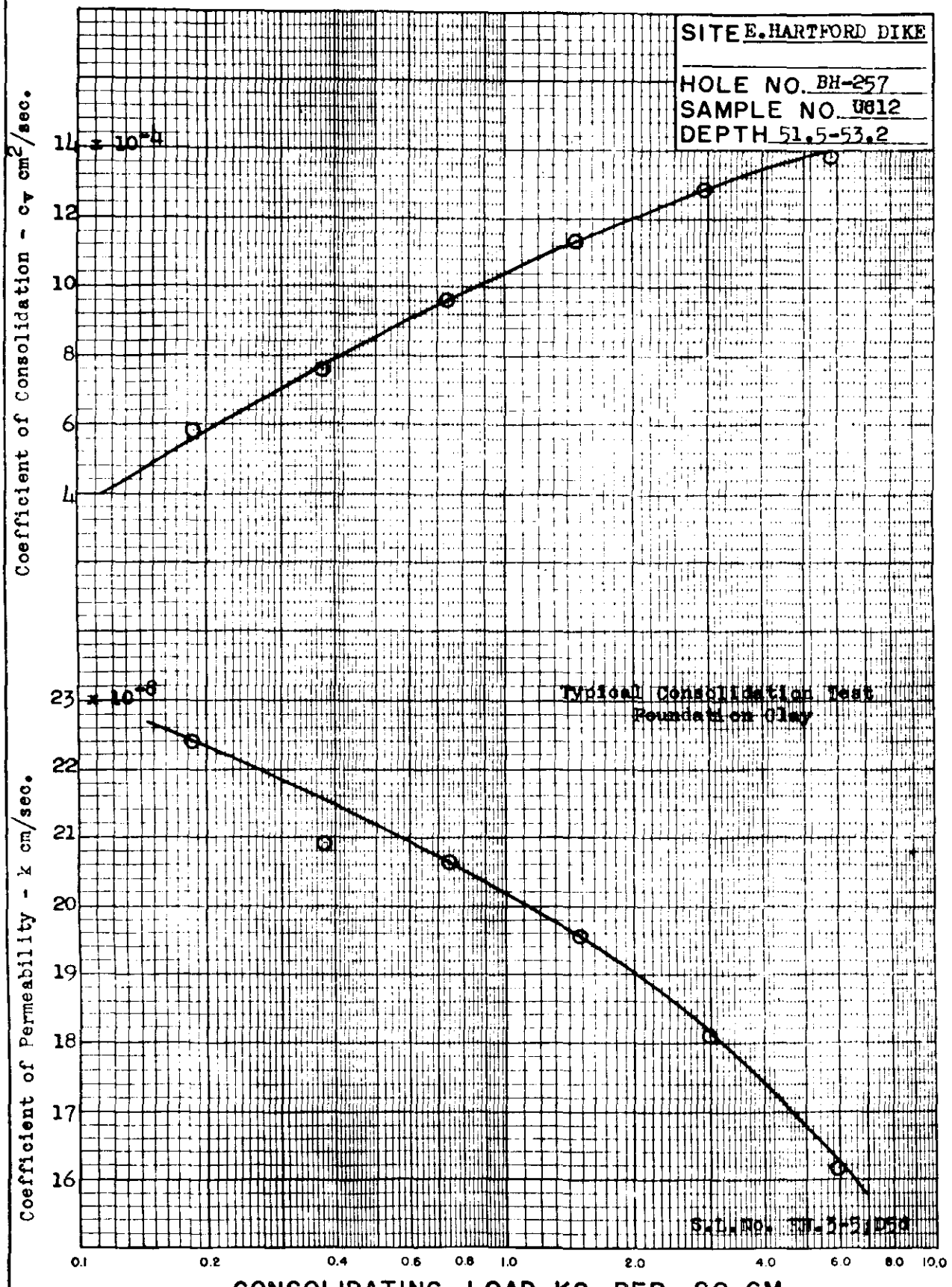
CONSOLIDATION CHARACTERISTICS



S. L. FORM NO. 71

U. S. GOVERNMENT PRINTING OFFICE 175305

CONSOLIDATION CHARACTERISTICS



S. L. FORM NO. 71

FLOOD CONTROL ENGINEERING DIVISION — SOILS LABORATORY

PLATE NO. 19

U. S. GOVERNMENT PRINTING OFFICE 175368

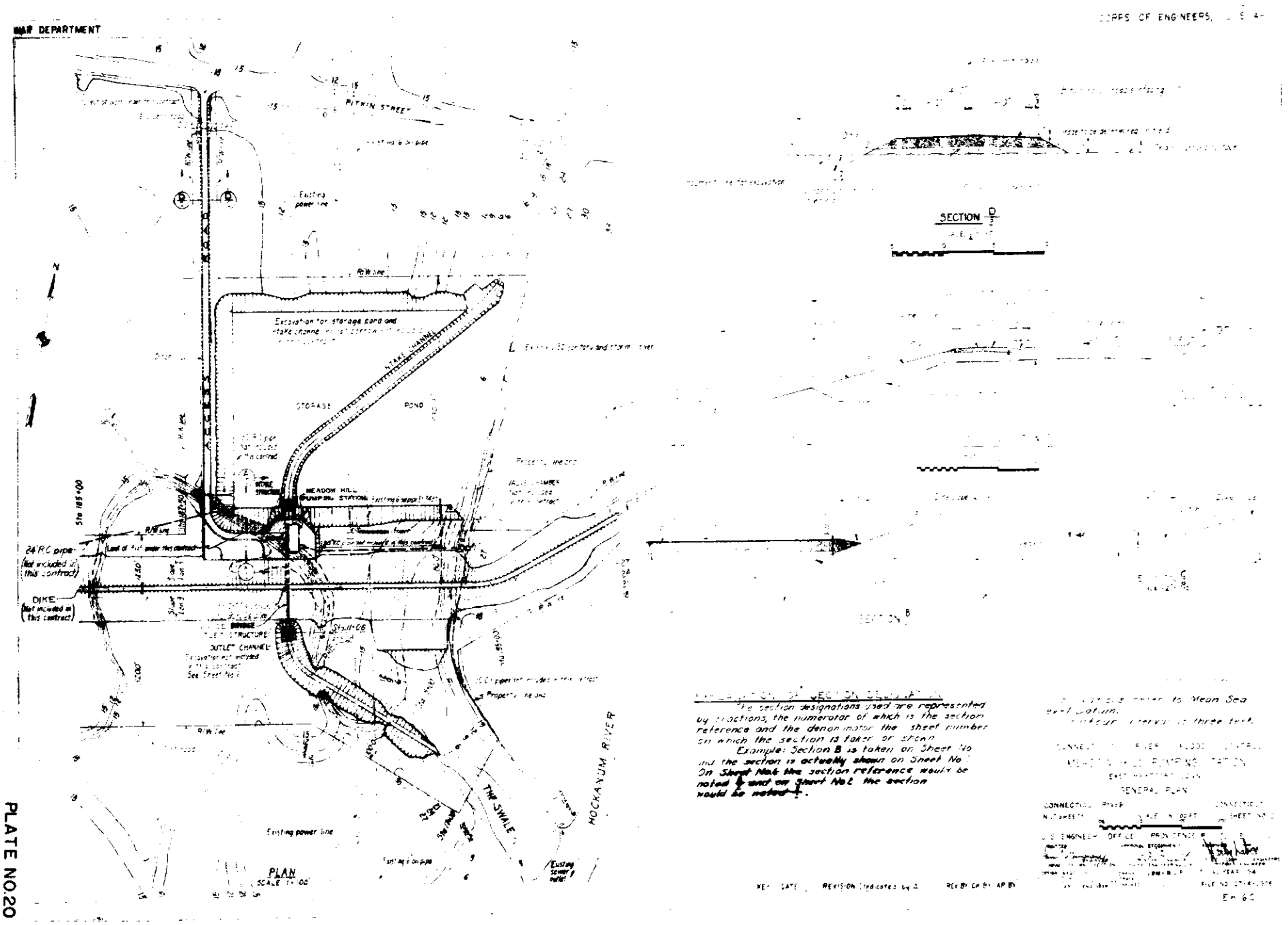

WAR DEPARTMENT
CORPS OF ENGINEERS
PITKIN STREET
Existing power line
R/W line
Excavation for storage pond and intake channel
INTAKE CHANNEL
STORAGE POND
MEADOW HILL PUMPING STATION
Sta 185+00
24" R.C. pipe (Not included in this contract)
DIKE (Not included in this contract)
OUTLET CHANNEL
Existing power line
THE SWALE
HOCKANUM RIVER
PLAN
SCALE 1"=100'
SECTION D/2
SECTION B
The section designations used are represented by fractions, the numerator of which is the section reference and the denominator the sheet number on which the section is taken or shown.
Example: Section B is taken on Sheet No and the section is actually shown on Sheet No. On Sheet No.6 the section reference would be noted 6/2 and on Sheet No.2 the section would be noted 2/2.
GENERAL PLAN
CONNECTICUT RIVER
U.S. ENGINEER OFFICE PROVIDENCE
KEY DATE REVISION (Indicated by A) REV BY CK BY AP BY

PLATE NO.20

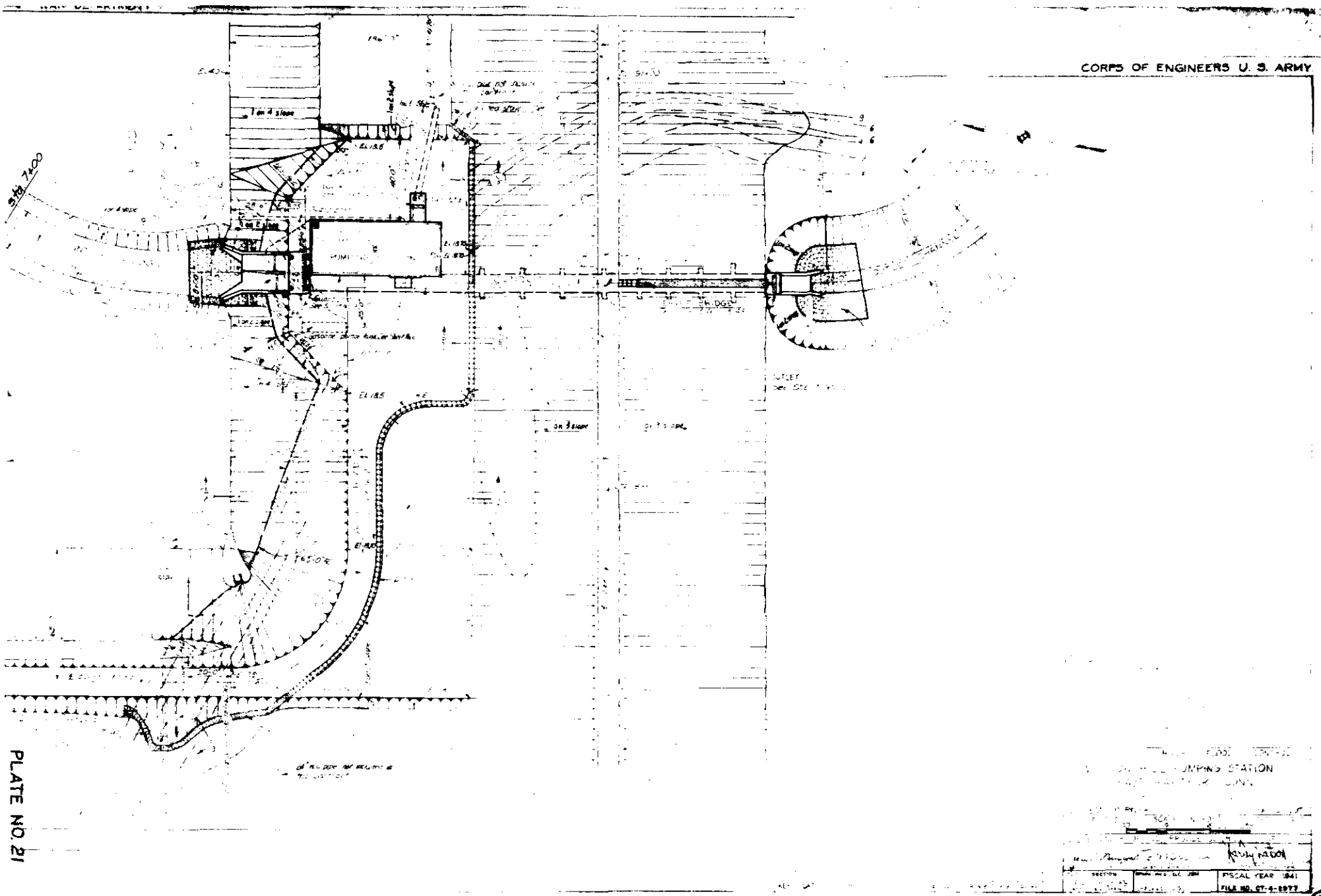

CORPS OF ENGINEERS U. S. ARMY
Sta 7+00
1 on 4 slope
1 on 2 slope
EL 18.5
EL 18.5
1 on 3 slope
OUTLET
PUMPING STATION
SECTION
FISCAL YEAR 1941
FILE NO. CT-4-2977

PLATE NO. 21

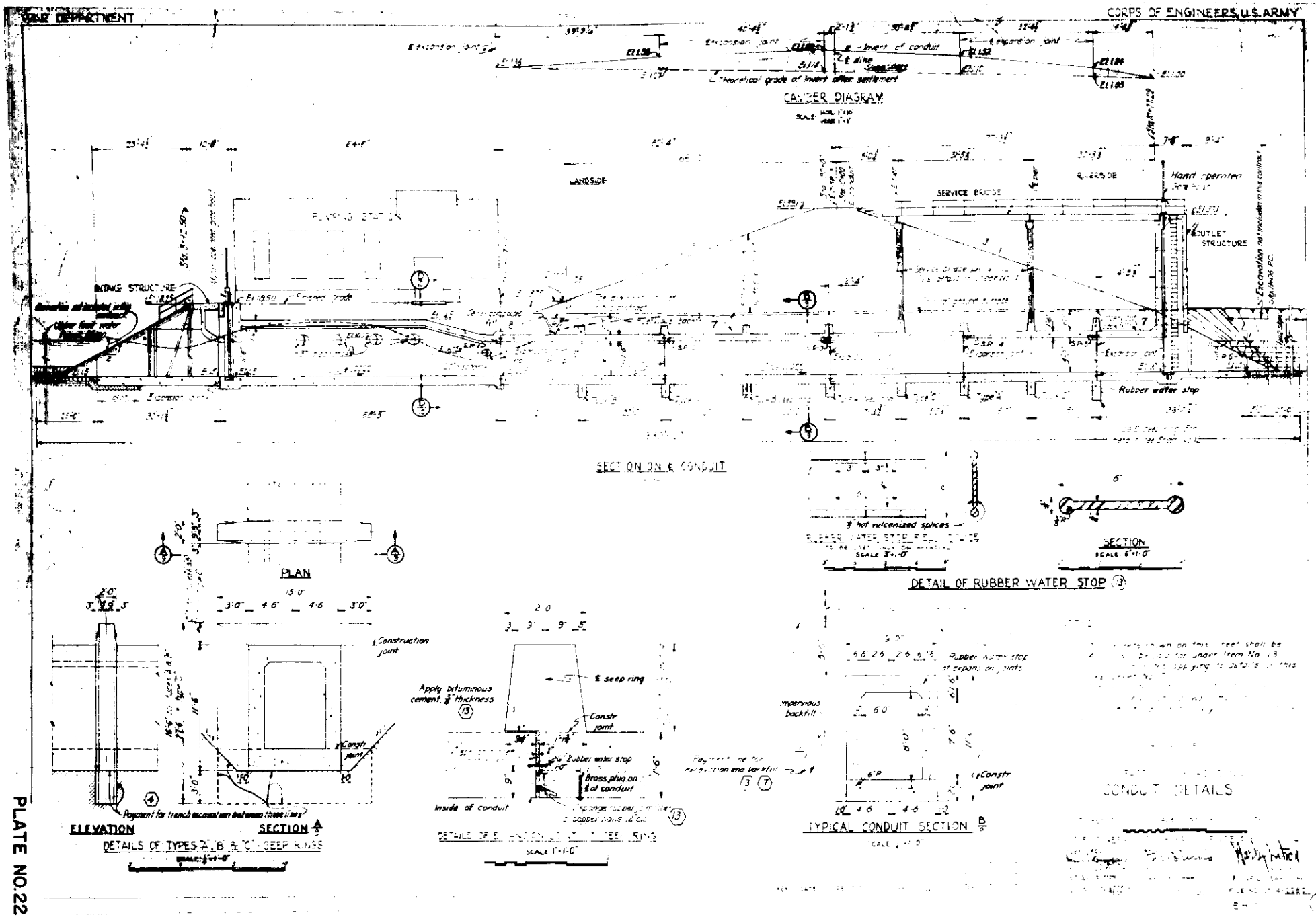
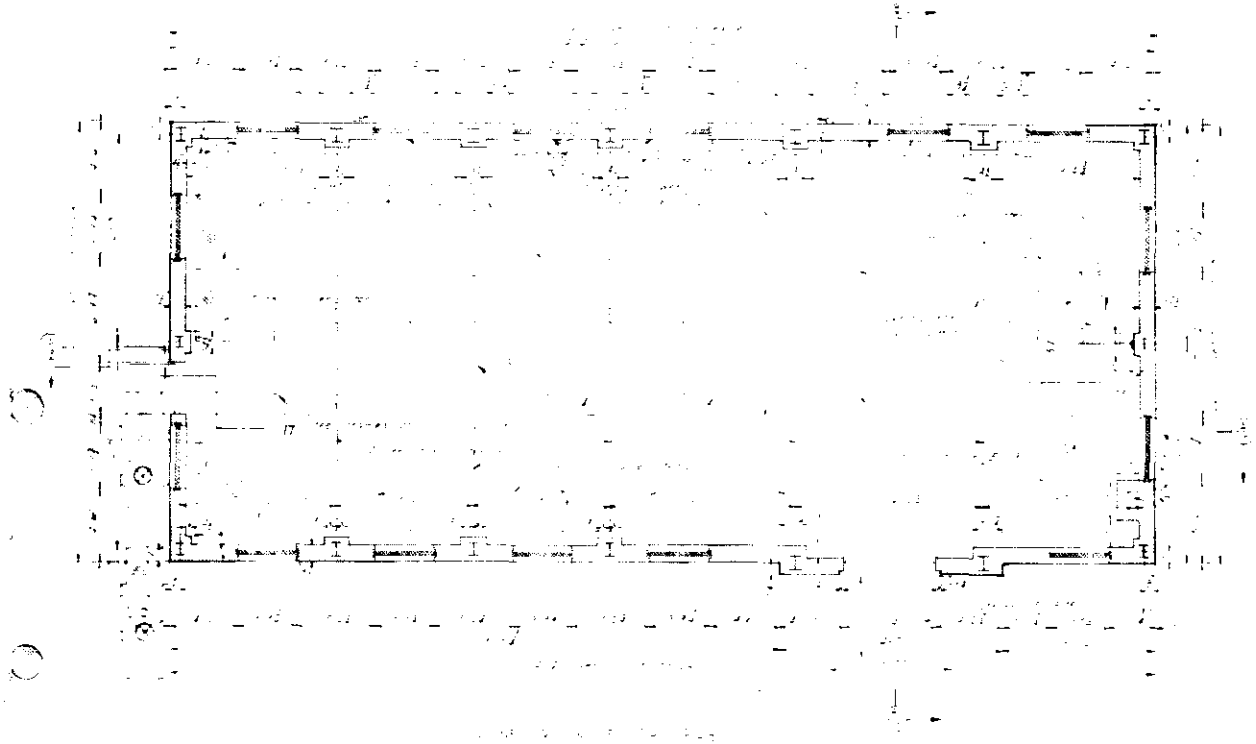
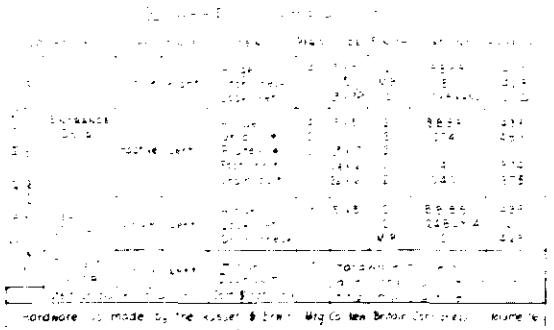

WAR DEPARTMENT
CORPS OF ENGINEERS, U.S. ARMY
CAMBER DIAGRAM
LANDSIDE
SERVICE BRIDGE
RIVERSIDE
INTAKE STRUCTURE
OUTLET STRUCTURE
Hand operated
Rubber water stop
SECTION ON ℄ CONDUIT
℄ hot vulcanized splices
SECTION
DETAIL OF RUBBER WATER STOP
PLAN
℄ Construction joint
Apply bituminous cement, ⅜" thickness
℄ seep ring
Constr joint
Rubber water stop
Brass plug on ℄ of conduit
Inside of conduit
Impervious backfill
Rubber water stop at expansion joints
Constr joint
Payment for trench excavation between these lines
ELEVATION
SECTION
DETAILS OF TYPES A, B & C SEEP RINGS
TYPICAL CONDUIT SECTION
CONDUIT DETAILS

PLATE NO. 22





MEADOW HILL PUMPING STATION

ENGINE ROOM FLOOR PLAN
ARCHITECTURAL

PLATE NO.23

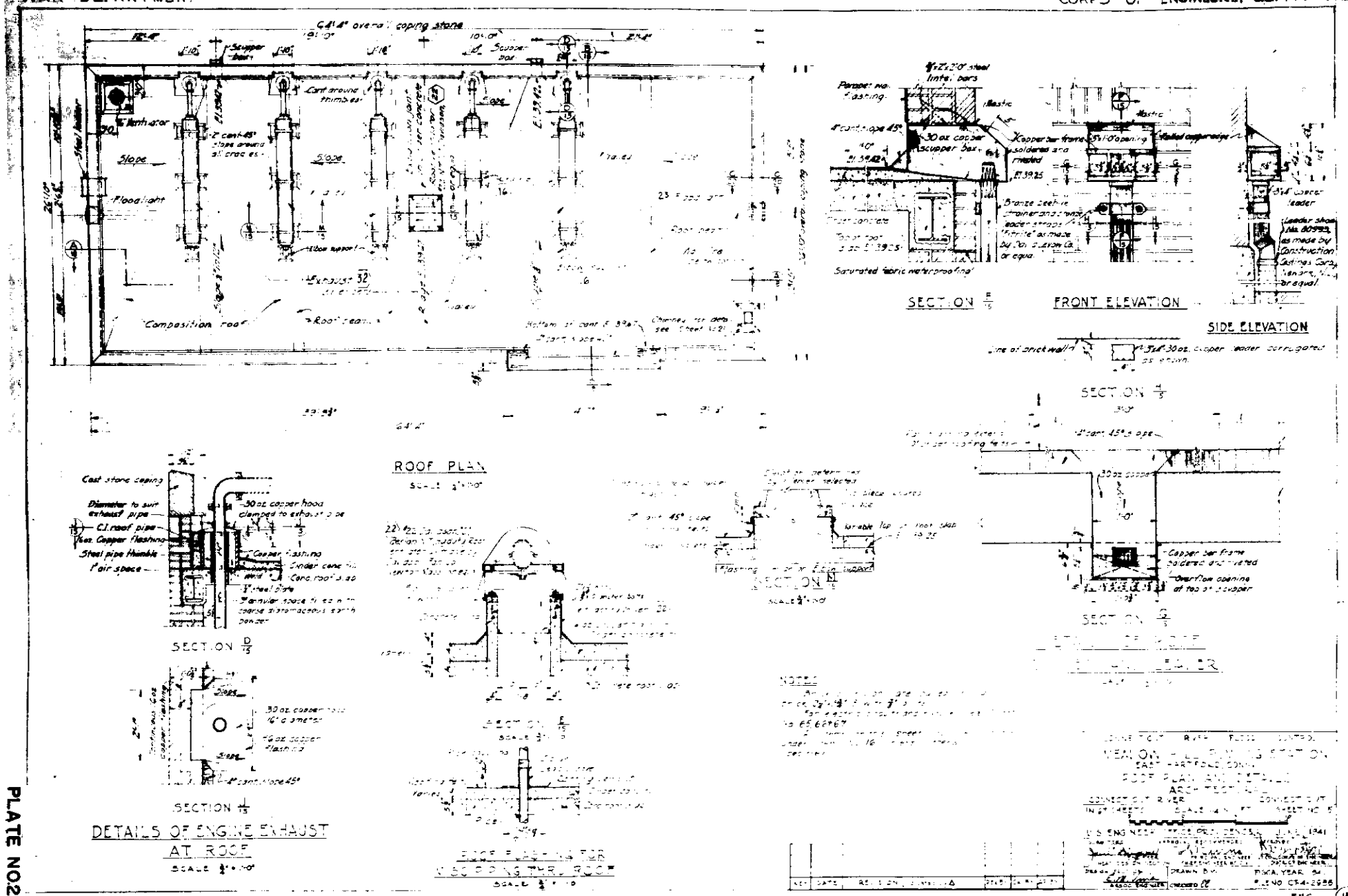

ROOF PLAN
SECTION D/5
DETAILS OF ENGINE EXHAUST AT ROOF
SECTION E/5
FRONT ELEVATION
SIDE ELEVATION
SECTION F/5
SECTION G/5
SECTION H/5
SECTION J/5
ROOF FLASHING FOR WOOD NAILING STRIP ROOF
NOTES
Cast stone coping
Composition roof
Floodlight
Ventilator
Slope
Steel ladder
Scupper box
30 oz. copper hood clamped to exhaust pipe
C.I. roof pipe
Steel pipe thimble
Air space
Copper flashing
Copper frame soldered and riveted
Overflow opening at top of scupper
Line of brick wall
Saturated fabric waterproofing
Bronze leaders
Copper leader
Leader shoe
Construction Castings Corp.
or equal

PLATE NO. 24

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

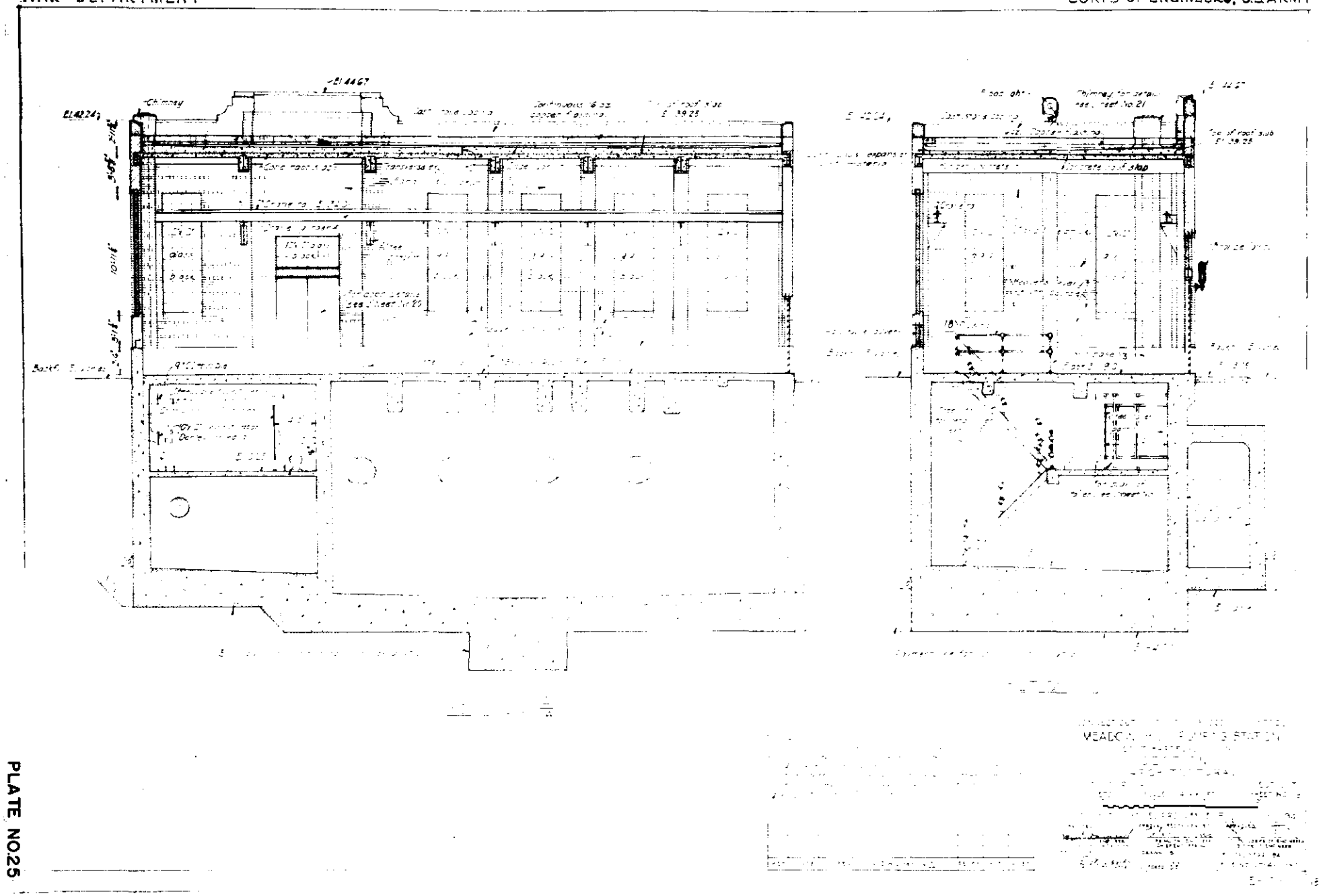
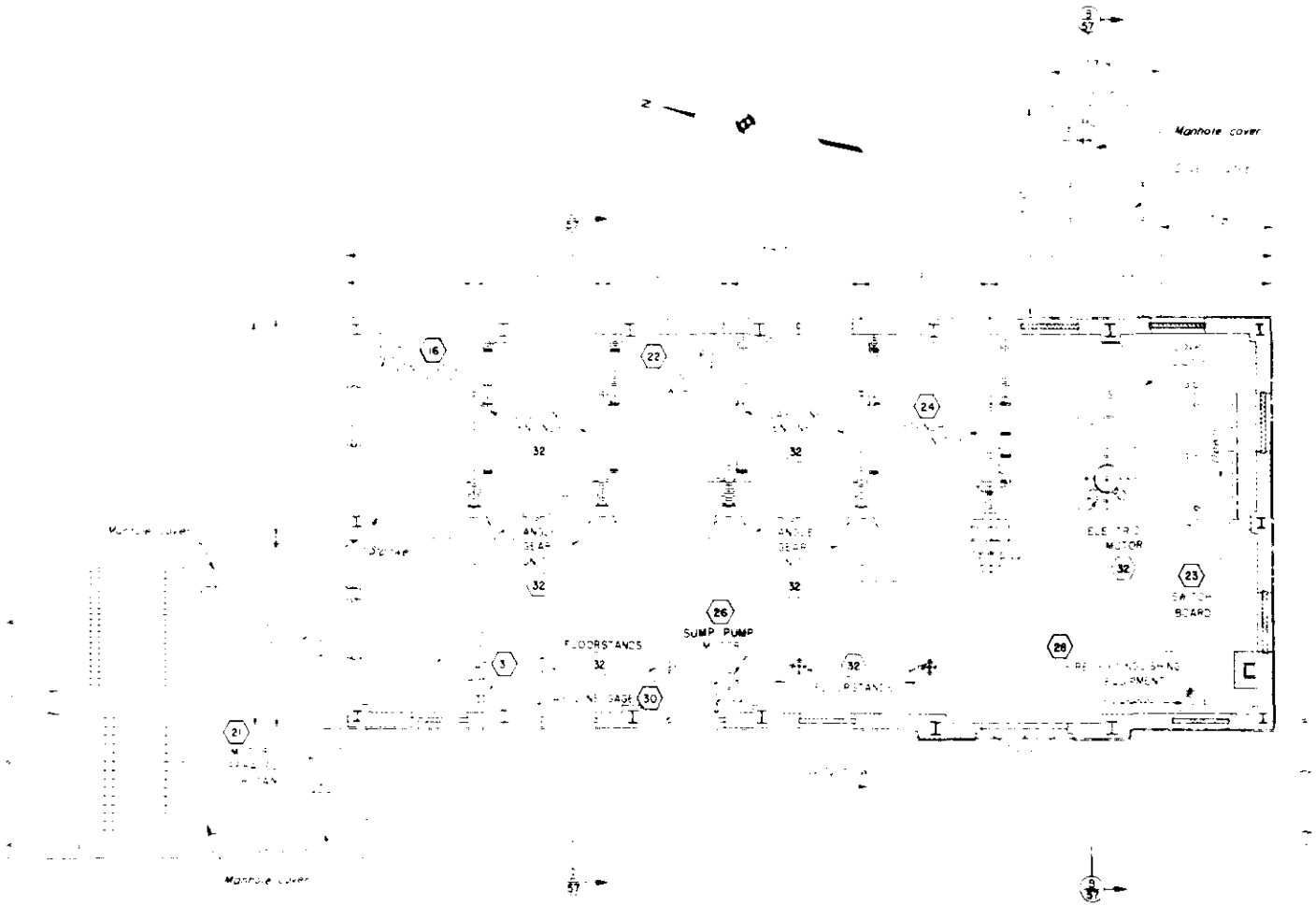


PLATE NO.25



ENGINE ROOM PLAN

NOTE

The gasoline engines, exhaust piping, silencers, couplings, gear units, 30" propeller pumps, 20" volute pump and motor, intake and discharge piping with gate valves, check valves and wall castings will be furnished by the Government.

REV	DATE	REVISION	REV BY	CK BY	AP BY

CONNECTICUT RIVER FLOOD CONTROL

MEADOW HILL PUMPING STATION

EAST HARTFORD, CONN.

GENERAL ARRANGEMENT OF EQUIPMENT NO. 1

CONNECTICUT RIVER — CONNECTICUT

IN 67 SHEETS — SCALE 1/4 IN. = 1 FT. — SHEET NO. 55

U. S. ENGINEER OFFICE, PROVIDENCE, R.I. — JUNE 1941

SUBMITTED — APPROVAL RECOMMENDED

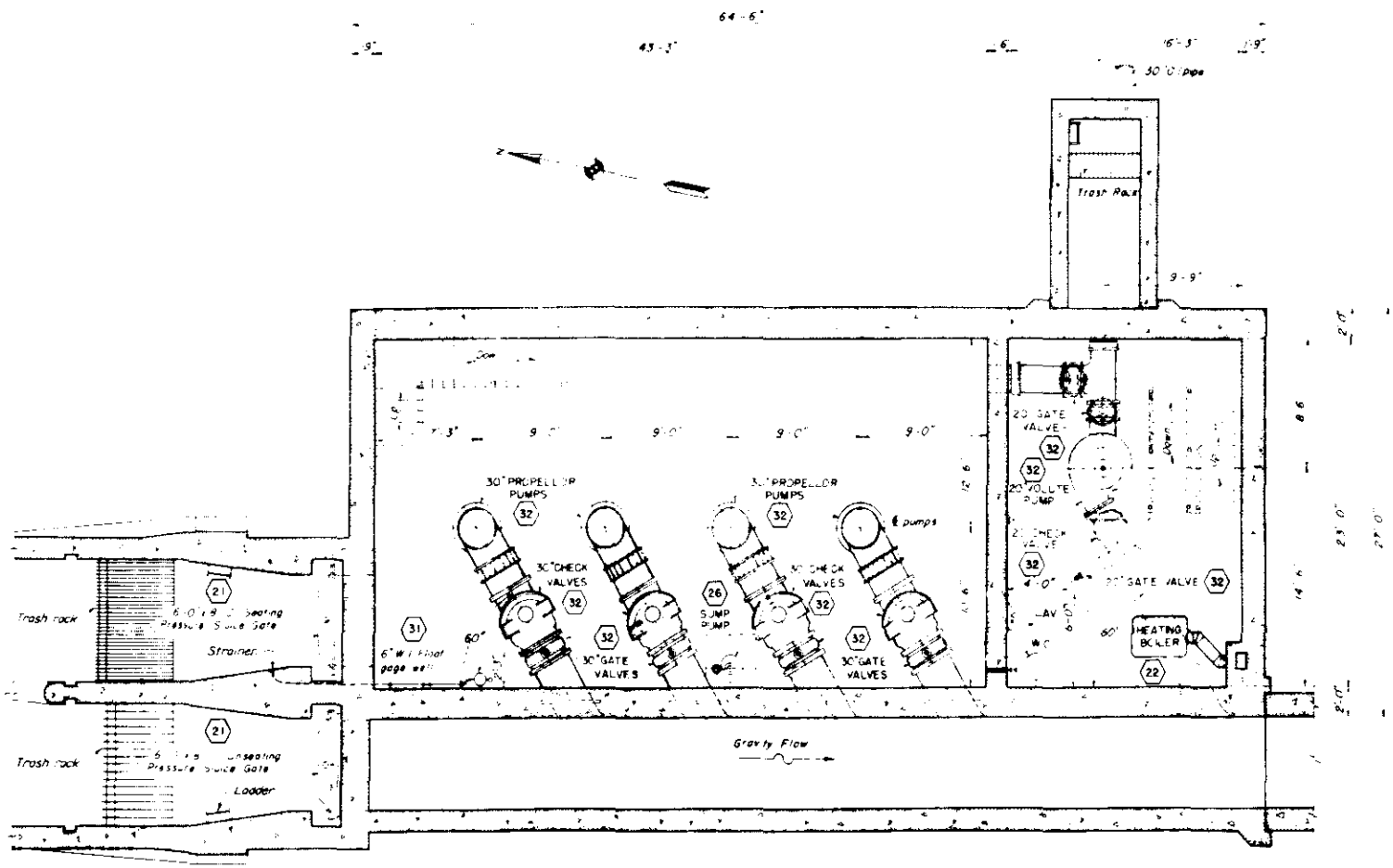
DESIGN SECTION — FISCAL YEAR 1941

FILE NO. CT-4-3026

EH. 6c

WAR DEPARTMENT

CORPS OF ENGINEERS U S ARMY



PUMP ROOM PLAN

NOTES

The gasoline engines, exhaust piping, silencers, couplings, gear units, 30" propeller pumps, 20" volute pump and motor, intake and discharge piping with gate valve, check valves and wall castings will be furnished by the Government.

CONNECTICUT RIVER FLOOD CONTROL

MEADOW HILL PUMPING STATION

EAST HARTFORD, CONN.

GENERAL ARRANGEMENT OF EQUIPMENT NO. 2

CONNECTICUT RIVER — CONNECTICUT

N 67 SHEETS — SCALE 1/4 IN = 1 FT — SHEET NO. 56

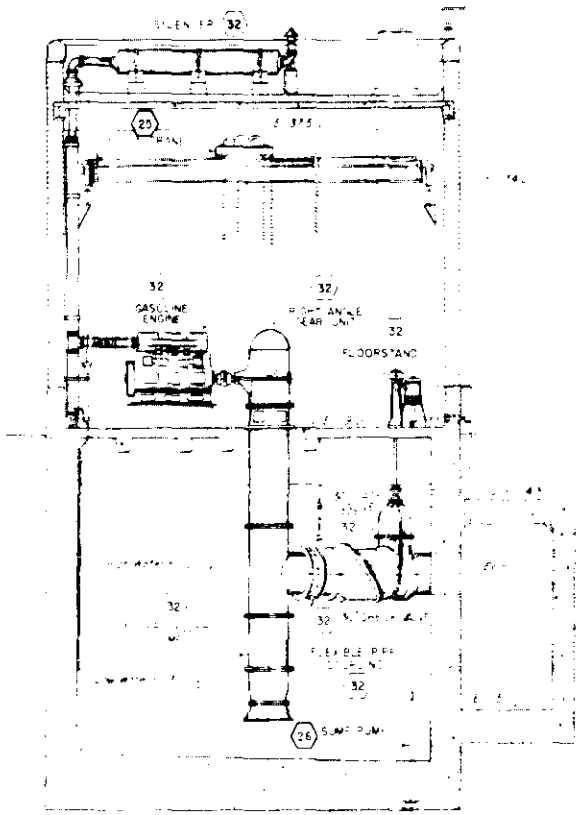
U S ENGINEER OFFICE, PROVIDENCE, R.I. — JUNE 1944

DESIGN SECTION — DRAWN BY — TRACED BY — CHECKED — FILE NO. 4-3027

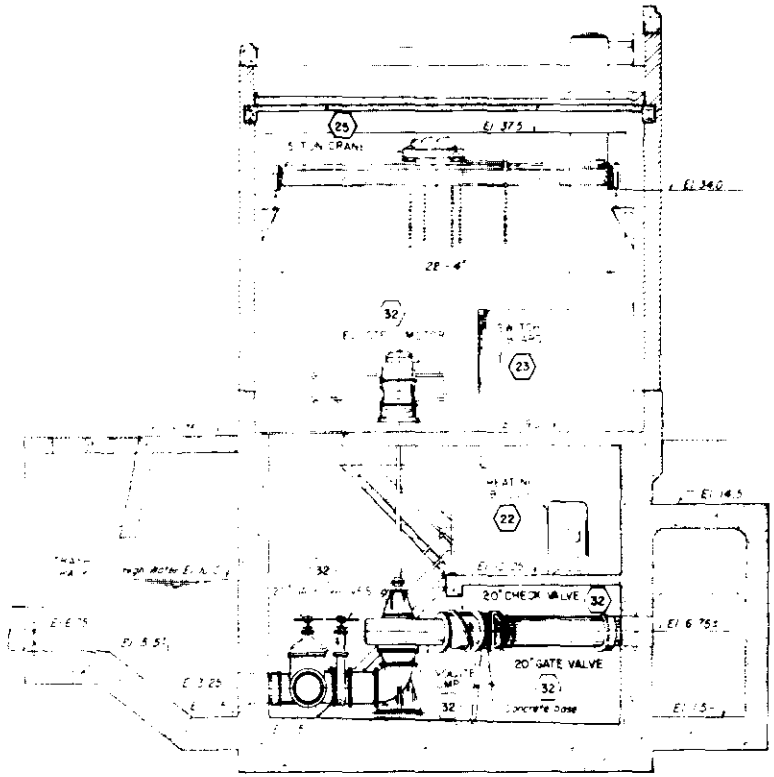
KEY	DATE	REVISION	REV BY	CK BY	AP BY

PLATE NO. 27

EH. 6c.



SECTION A/55



SECTION B/55

NOTES:

The gasoline engines, exhaust piping, silencers, couplings, gear units, 30" propeller pumps, 30" volute pump and motor, intake and discharge piping with gate valves, check valves and wall castings will be furnished by the government.

CONNECTICUT RIVER FLOOD CONTROL

MEADOW HILL PUMPING STATION

EAST HARTFORD, CONN.

GENERAL ARRANGEMENT OF EQUIPMENT NO. 3

CONNECTICUT RIVER — CONNECTICUT

SCALE 1/4 IN = 1 FT — SHEET NO. 57

ENGINEER OFFICE PROVIDENCE, R.I. — JUNE 1941

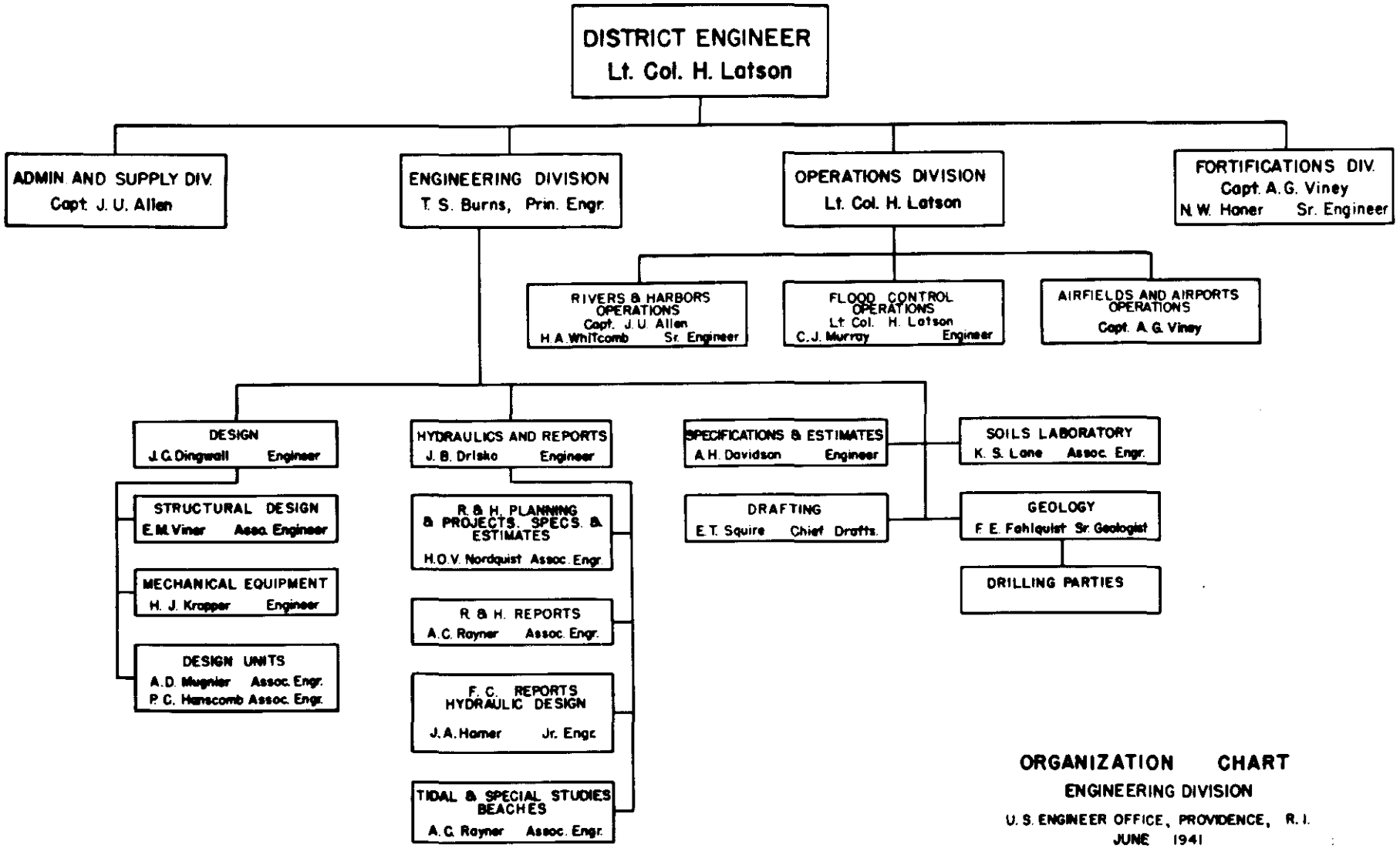
FILE NO. CT-4-3028

EH. 6c

57

PLATE NO. 28

PLATE NO. 29



ORGANIZATION CHART
ENGINEERING DIVISION
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.
JUNE 1941

PLATE NO. 30

INDEX
MEADOW HILL PUMPING STATION

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4. Boiler Room Floor	29-30
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1. Concrete Roof Slab	125
2. Roof Beams	126-128
3. Crane Beams	129-131
4. Crane Columns	132-146
5. Crane Brackets	147-150

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 1

Subject: Meadow Hill Pumping Station

Computation: Engine Room Floor

Computed by: E.M.V. Checked by: Date: April 24, 1941

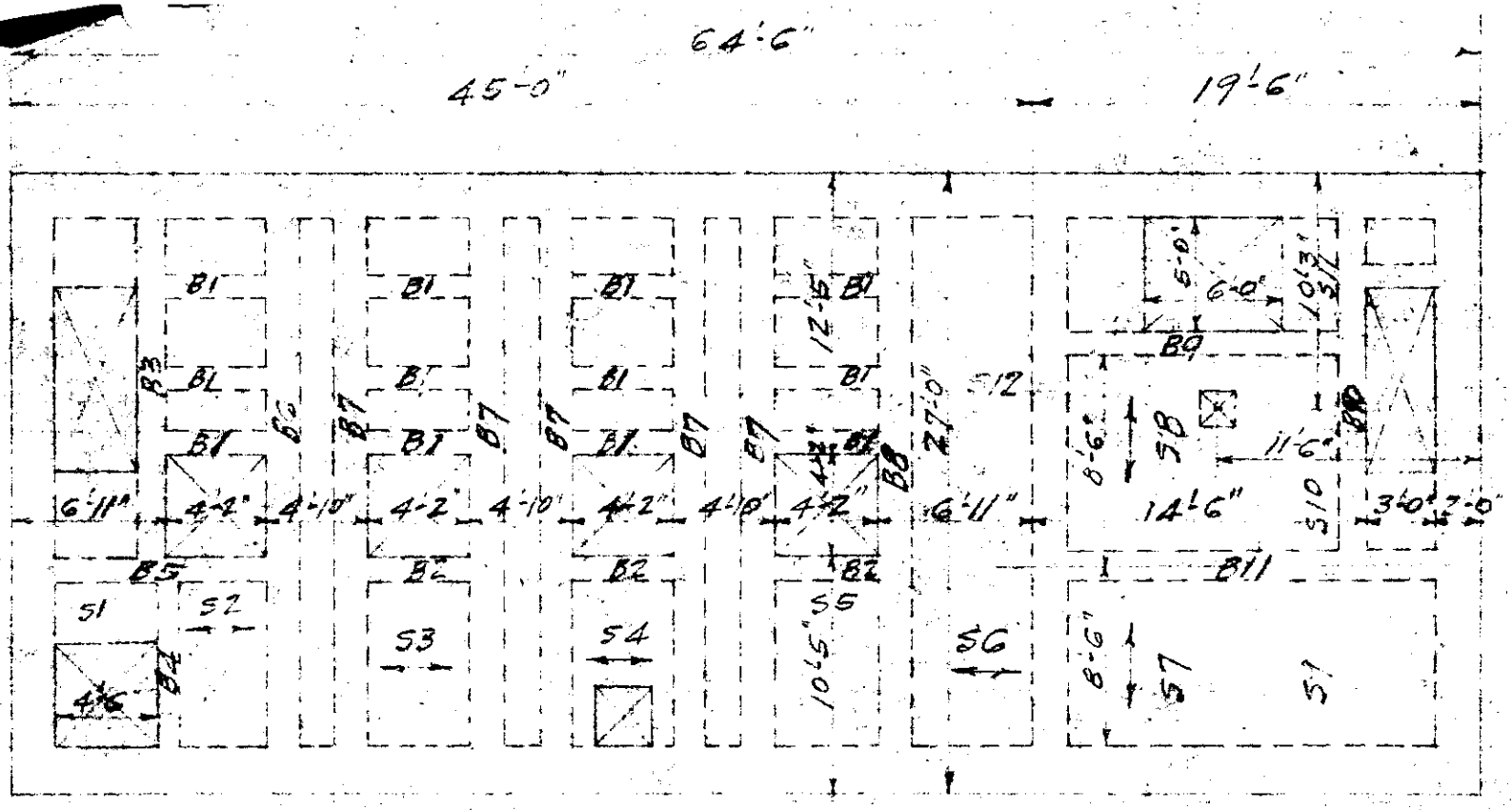
U. S. GOVERNMENT PRINTING OFFICE 3—10528

Equipment loads –

1. Gasoline engine	6,000#
2. Conc. block under engine	3,000
3. Right angle gear unit	4,000
4. Propeller pump	8,000
5. Thrust of propeller pump	7,000
6. Gate valve, check valve and discharge pipe full of water	16,000
7. Motor for volute pump	3,000
8. Conc. base under volute pump motor	1,200
9. Volute pump and suction elbow full of water	8,000
10. Thrust on volute pump	5,000
11. Standby unit	16,000
12. Conc. base under standby unit	8,500
13. Switchboard	4,000
14. Hand operated crane, wheels 5'-2" c.c. max. wheel load	6,4[illegible]
15. Heating boiler	4[illegible]
16. Volute pump suct. piping with water	6,[illegible]
17. " " disch. " "	[illegible]

WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Meadow Hill Pumping Station
Computation: Engine Room Floor
Computed by: L. M. V. Checked by: Date: April 24, 1941
Page: 2



Plan of Floor Framing

Assumed uniform Live Load on parts of slab not occupied by equipment = 250 #/□'

Assumed uniform Live Load on slab contributing load to beams = 200 #/□'

U. S. GOVERNMENT PRINTING OFFICE 3—10688

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Meadow Hill Pumping Station

Computation: Engine Room Floor

Computed by: E.M.V. Checked by: W. A. L. Jr. Date: April 24, 1941.

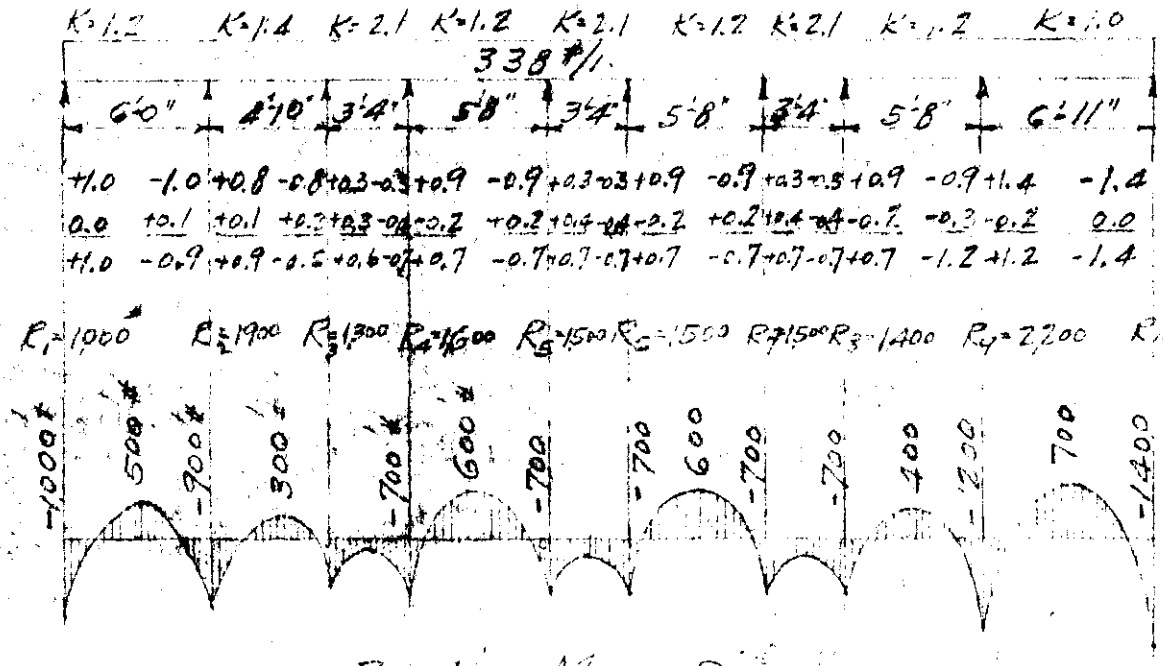
U. S. GOVERNMENT PRINTING OFFICE 3—10825

Design of slabs "S1" to "S6" inclusive.

Assuming slab 7" + lin. wt = 88 #/□'

Live Load = 250

Total = 338 #/□'



Bending Mom. Diagram

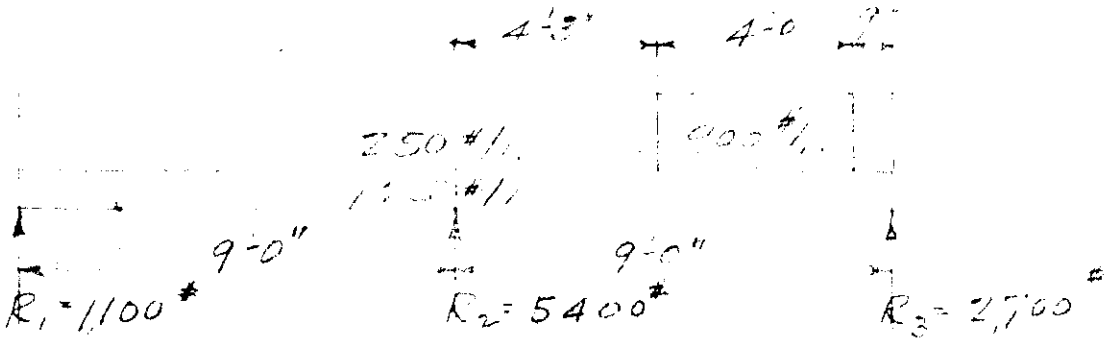
Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.V. **Checked by** [illegible] **Date** April 22, 1941

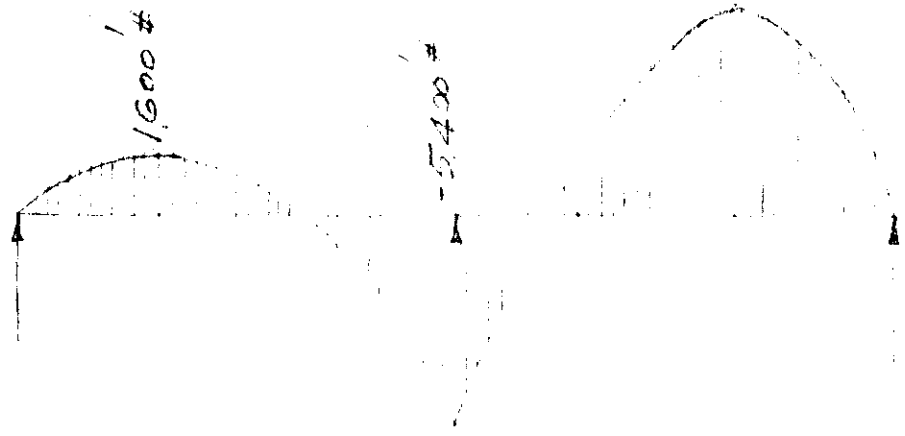
U. S. GOVERNMENT PRINTING OFFICE 3—10538

Slabs 57 & 58.



+2.5	-2.5	+3.0
-2.5	-0.7	-0.6
-0.4	-1.3	+3.6
+0.4	-1.1	-1.2
-0.6	+0.2	+0.2
+0.6	0.0	0.0
0.0	-5.4	+5.4

-7.2
+1.2
-0.3
+0.3
-0.6
+0.6
0.0



Bending Moment Diagram

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

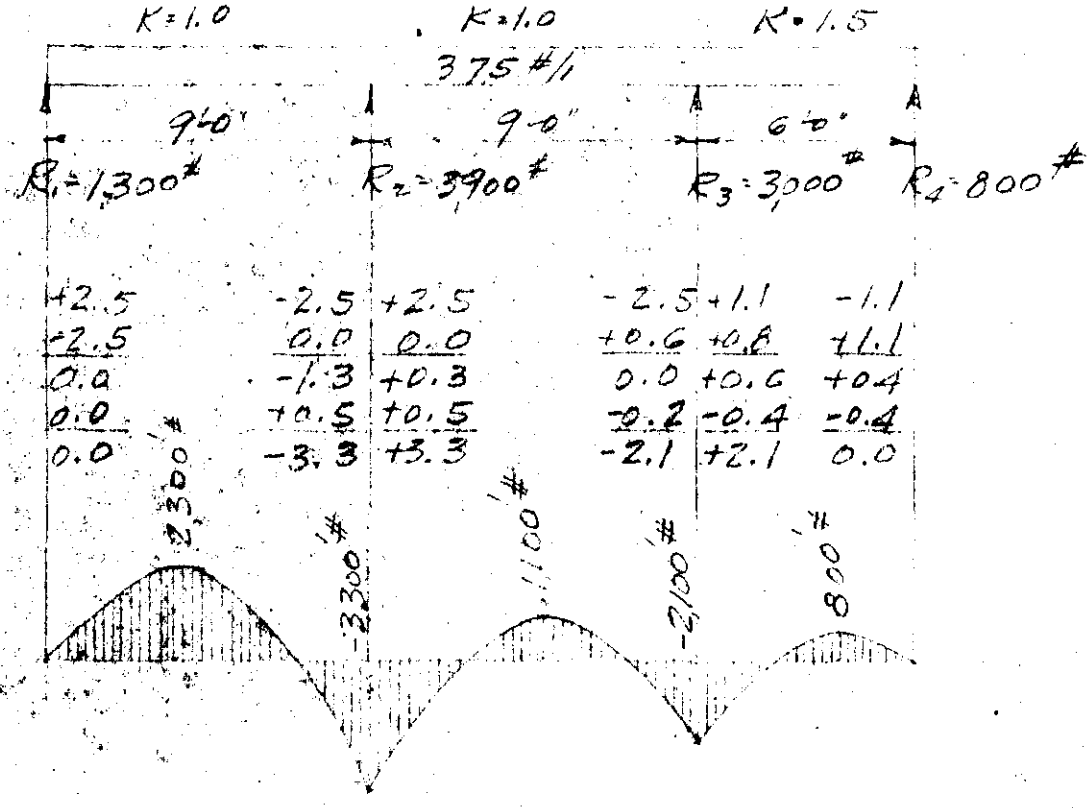
Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.V. **Checked by** W.A.J. Jr. **Date** April 29, 1941

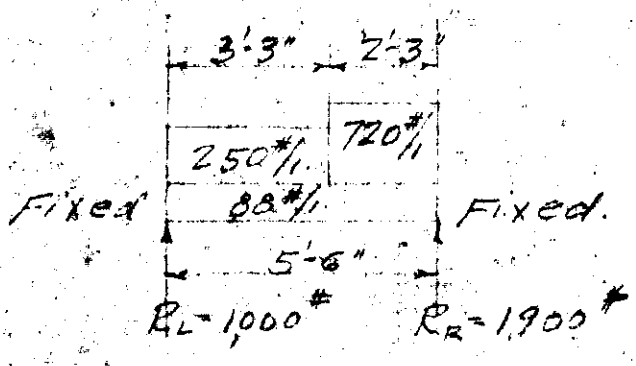
U. S. GOVERNMENT PRINTING OFFICE 3—10583

Slabs "S9", "S10", "S11"



Bending Mom. Diagram

Slab "S12".



Fixed Mom. at R_L = 1,200'#

" " " R_R = 1,800'#

Max. pos. mom. = 700'#.

Subject: Meadow Hill Pumping Station
Computation: Engine Room Floor
Computed by: E.M.V. Checked by: [illegible] Date: April 30, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10838

Design of floor slabs -

Slabs S1 to S6 inclusive.

Max. pos. mom. = 700'#

" neg. " = 1,400 #

" shear = 1200 #

Effective depth reqd = $\sqrt{\frac{1400}{147}}$ = 3.1

Total depth reqd for conduit encasement = 7", d = 5.2

Unit shear = $\frac{1200}{12 + \frac{7}{8} \times 5.2}$ = 22 #/□" O.K.

A_s for pos. mom. = $\frac{700 \times 12}{\frac{7}{8} \times 5.2 \times 18{,}000}$ = 0.10□"

A_s for neg. " = $\frac{1400 \times 12}{\frac{7}{8} \times 5.2 \times 18{,}000}$ = 0.21□"

Try $\frac{1}{2}$"□ bars 12" c.c.

Unit bond-stress = $\frac{1200}{2.00 \times \frac{7}{8} \times 5.2}$ = 132 #/□" O.K.

Make slab 7" thk.

Use $\frac{1}{2}$"□ bars 12" c.c. top & bot.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 7

Subject: Meadow Hill Pumping Station

Computation: Engine Room Floor

Computed by: E.M.V. Checked by: [illegible] Date: April [illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Design of slabs "S7" & "S8"

Max. pos. mom. for "S7" = 1,600 #

" " " " "S8" = 5,3[illegible] #

" neg. " = 5,[illegible] #

" shear = 27[illegible] #

Effective depth req'd by mom. = [illegible]

Total depth req'd for conduit encasement = [illegible] 8.2

Unit shear = $\frac{2700}{12 \times \frac{7}{8} \times 8.2}$, 31.4 #/□"

A_s for pos. mom. = $\frac{1600 \times 12}{\frac{7}{8} \times 8.2 \times 18000}$, 0.15 □"

$\frac{5300 \times 12}{\frac{7}{8} \times 8.2 \times 18000}$ = 0.47 □"

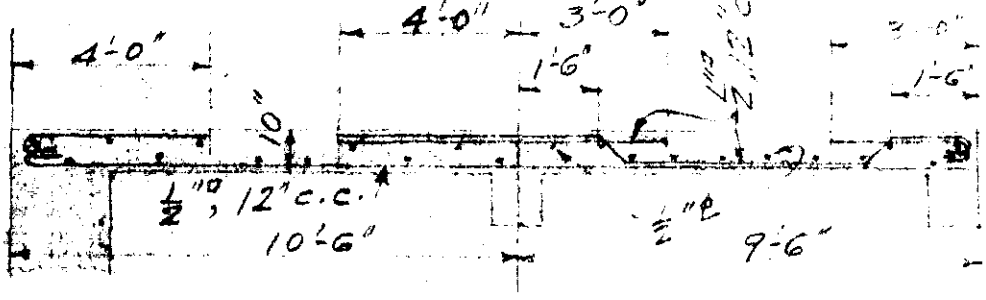
A_s for neg. mom. = $\frac{5.4}{5.3} \times 0.47$ = 0.50 □"

Use ½"□ bars 12" c.c. for "S7".

Use ½"□ " 6" c.c. for pos. mom. for "S8"

Use ½"□ " 6" c.c. " neg. mom.

Make slab 10" thk.



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 7

Subject: Meadow Hill Pumping Station

Computation: Engine Room Floor

Computed by: E.M.V. Checked by: [illegible] Date: April 30, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Design of slabs "S7" & "S8".

Max. pos. mom. for "S7" = 1,600'#

" " " " "S8" = 5,300'#

" neg. " = 5,400'#

" shear = 2700#

Effective depth req'd by mom. $= \sqrt{\frac{5300}{123}} = 6.6$

Total depth req'd for conduit encasement = 10", d = 8.2".

Unit shear $= \frac{2700}{12 \times \frac{7}{8} \times 8.2} = 31.4$ #/□"

As for pos. mom. $= \frac{1600 \times 12}{\frac{7}{8} \times 8.2 \times 18000} = 0.15$ □"

$\frac{5300 \times 12}{\frac{7}{8} \times 8.2 \times 18000} = 0.49$ □"

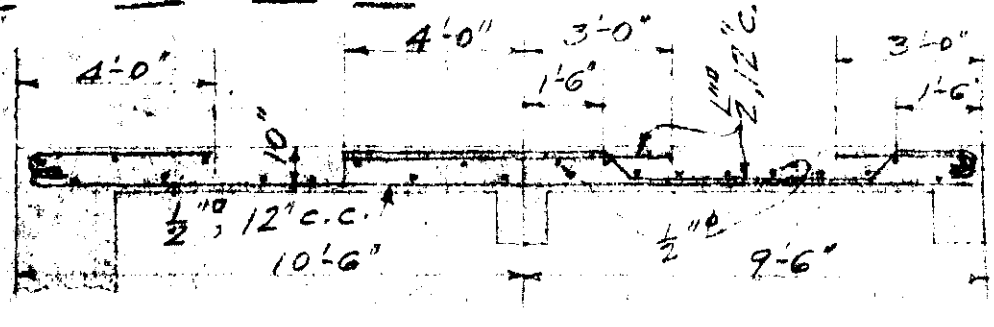
As for neg. mom. $= \frac{5.4}{5.3} \times 0.49 = 0.50$ □"

Use ½"□ bars 12" c.c. for "S7".

Use ½"□ " 6" c.c. for pos. mom. for "S8"

Use ½"□ " 6" c.c. " neg. mom.

Make slab 10" thk.



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 5

Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.V. **Checked by** [illegible] **Date** April 30, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Design of slabs "S9", "S10", & "S11".

Max. pos. mom. = 2,300'#

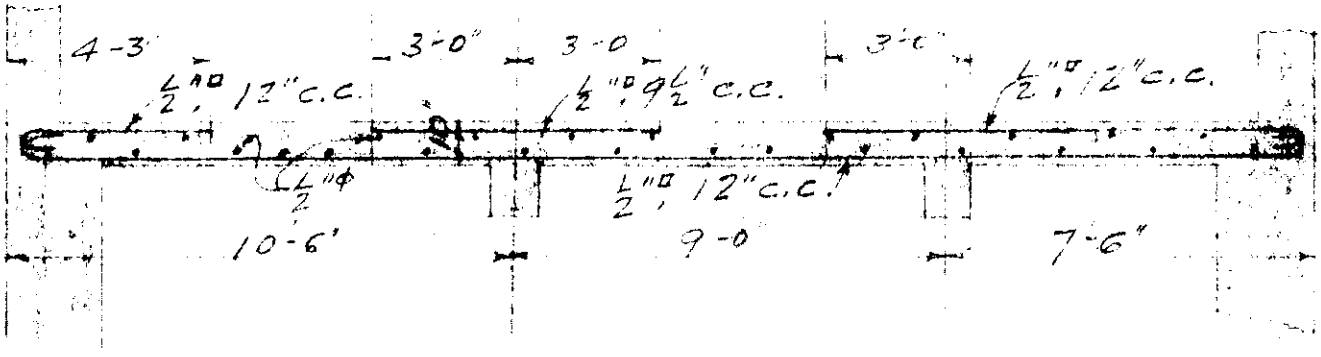
" neg. " = 3,300'#

" shear = 1,800#

Slab is 10" thk. "d" = 8.2".

As for pos. mom. = $\frac{2,300 \times 12}{\frac{7}{8} \times 8.2 \times 18,000}$ = 0.21 □" = $\frac{1}{2}$"□, 12" c.c.

As for neg. mom. = $\frac{3,300 \times 12}{\frac{7}{8} \times 8.2 \times 18,000}$ = 0.31 □" = $\frac{1}{2}$"□, 9½" c.c.



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 9

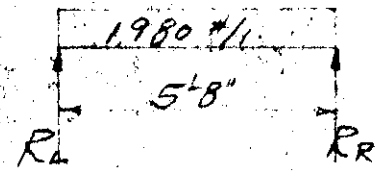
Subject: Meadow Hill Pumping Station

Computation: Engine Room Floor

Computed by: E.M.Y. Checked by: [illegible] Date: April 30, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10628

Beam "B1"



$R_L = R_R = 5600\#$

$M = \frac{1}{8} \times 1980 (5.67)^2 = 8{,}000'\#$

$d = \sqrt{\frac{8000}{123}} = 8''$

Assume bm. 12"×12", d" = 9.5"

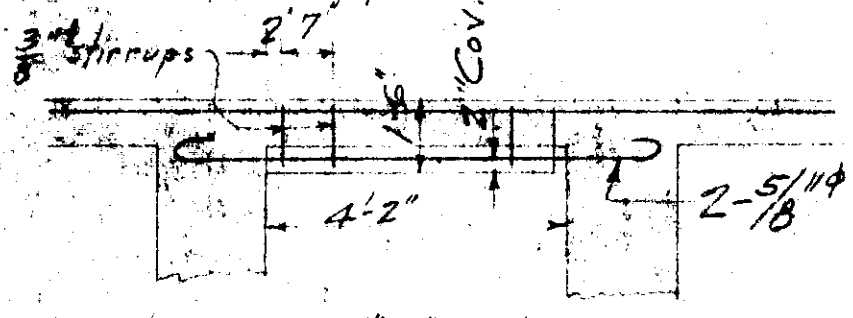
Unit shear $= \frac{5600}{12 \times \frac{7}{8} \times 9.5} = 56\#/\square''$

$A_s = \frac{8000 \times 12}{\frac{7}{8} \times 9.5 \times 18{,}000} = 0.64\square''$

Try 2-5/8"φ @ 0.31□" = 0.62□". Use

Unit bond $= \frac{5600}{2 \times 1.96 \times \frac{7}{8} \times 9.5} = 172\#/\square''$ Special anch.

Note: Make bm 1'6" deep to insure rigidity.



Beam "B1" Stem 1'-0" wide.

Note: Top steel over supports to be provided by extending floor steel.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 10

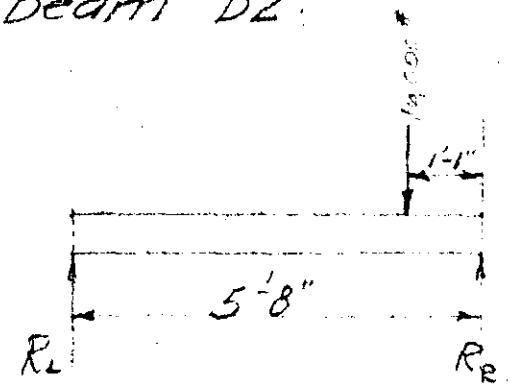
Subject: Meadow Hill Pumping Station

Computation: Engine Room Floor

Computed by: E.M.V. Checked by: [illegible] Date: May 1, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Beam "B2"



Wt. of right ∠ gear unit = 4,000#

" " pump = 8,000

Total = 12,000#

Impact = 12,000

Thrust = 7,000

Piping = 8,000

Total = 39,000#

Live plus impact load = $\frac{39,000}{5.67 \times 4}$ = 1720#/'.

Beam, say 300

Total = 2,020#/'.

Weight of discharge pipe hung [illegible]

$R_L = 2020 \times \frac{5.67}{2} + \frac{1.08}{5.67} \times 16,000 = 8,800$#

$R_R = 2020 \times \frac{5.67}{2} + \frac{4.58}{5.67} \times 16,000 = 18,600$#

Max. Moment = $8,800 \times 4.58 - 2020 \times \frac{4.58^2}{2} = 19,[illegible]$#

Effective depth required = $\sqrt{\frac{[illegible]}{[illegible]}}$ = 12.5"; d = [illegible]

Unit shear = $\frac{[illegible]}{\frac{7}{8} \times 18 \times [illegible]}$ = [illegible]#/□"

$A_s = \frac{17,100 \times 12}{\frac{7}{8} \times 15.5 \times 18,000}$ = 0.94 □" – [illegible] 4 - 5/8 [illegible]

Unit Bond = $\frac{[illegible]}{4 \times 1.98 \times \frac{7}{8} \times [illegible]}$ = 175# [illegible]

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

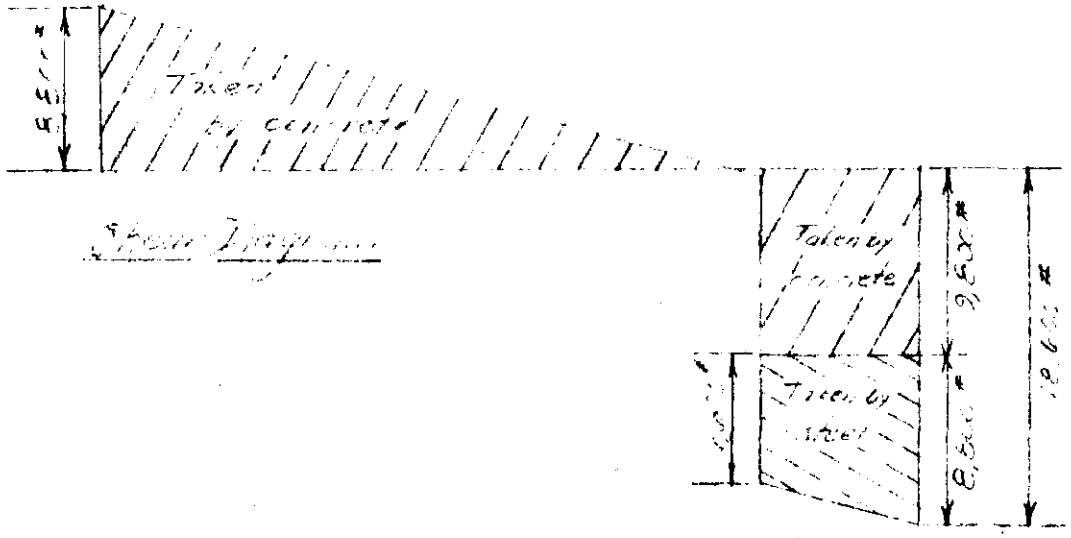
Subject Meadow Hill Pumping Station

Computation Engine Room Floor

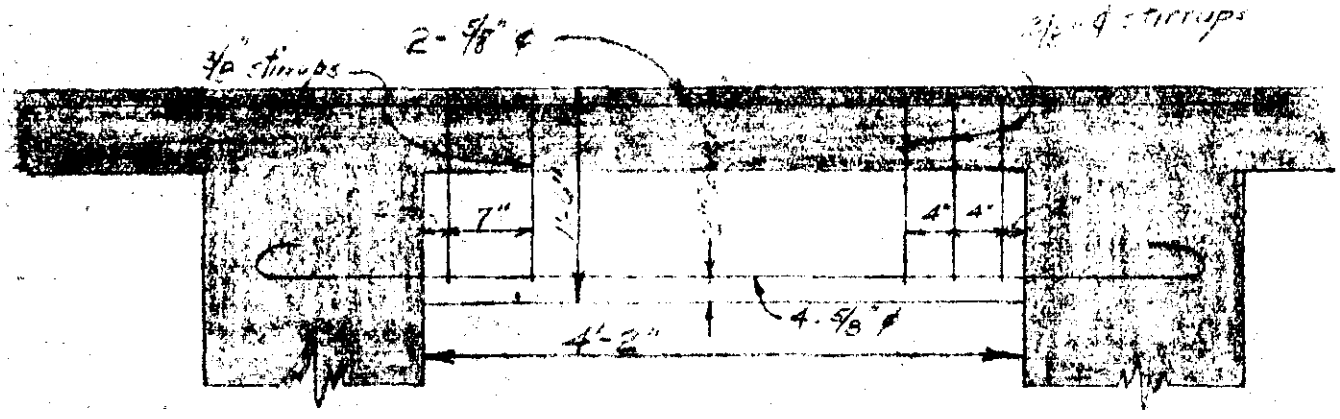
Computed by [illegible] Checked by _____ Date June 12, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10526

Beam "B2" (cont.)



Shear Diagram



Beam "B2" - Steel 1'-0" wide

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

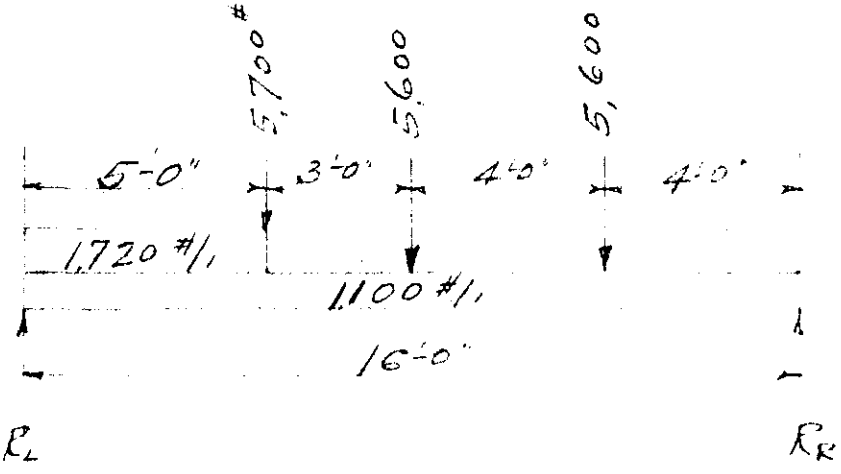
Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.V. **Checked by** [illegible] **Date** May 1, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Beam "B3"



L.L. from floor = 200 × 2.5 = 500 #/'

D.L. " " = 88 × 2.5 = 220

" " bim., say 300

Total = 1,100 #/'

R_L – 2 × 5,600 × 6.0 = 67,200

5,700 × 11.0 = 62,700

1,720 × 5.0 × 13.5 = 116,000

245,900

245,900 / 16.0 = 15,400 #

1100 × 8.0 = 8,800

R_L = 24,200 #

R_R = 18,900 #

$M = 18,900 \times 8.0 - 5600 \times 4.0 - 1100 \frac{(8.0)^2}{2} = 93,600$ #.

Subject: Meadow Hill Pumping Station
Computation: Engine Room Floor
Computed by: E.M.Y. Checked by: [illegible] Date: May 1, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Beam "B3" (Continued from sheet #11)

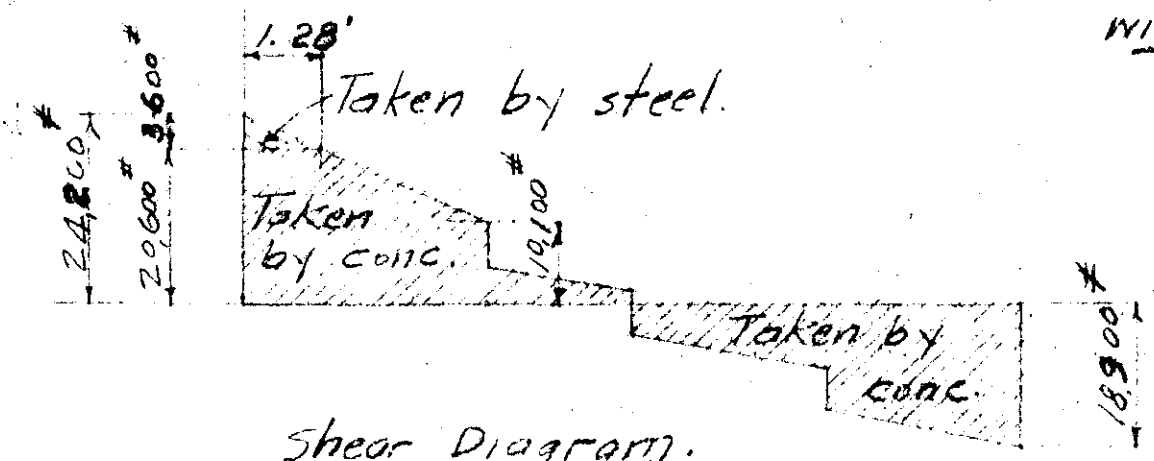
Effective depth reqd $= \sqrt{\frac{93{,}600 \times 12}{123 \times 16}} = 23.9''$

Unit shear $= \frac{24200}{16 \times \frac{7}{8} \times 23.9} = 72.4\ \#/\square''$

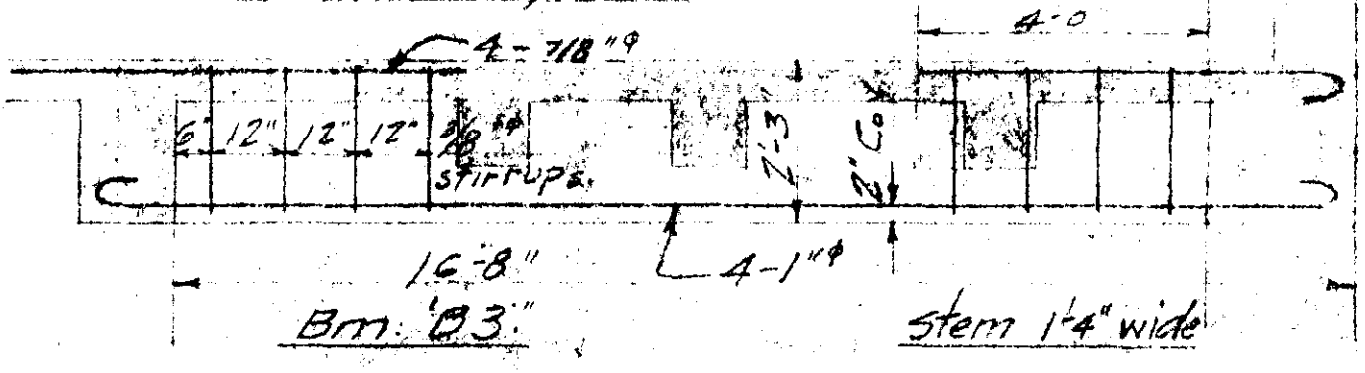
Make beam 2'-3" deep. Assume "d" = 24.5"

$A_s = \frac{93{,}600 \times 12}{\frac{7}{8} \times 24.5 \times 18{,}000} = 2.91\ \square'' = 4\text{-}1''\phi\ @\ 0.78 = 3.12\ \square''$

With 2-1"ϕ bars bent up unit bond $= \frac{24200}{2 \times 3.14 \times \frac{7}{8} \times 24.5}$
$= 180\ \#/\square''$ O.K.
with special anch.



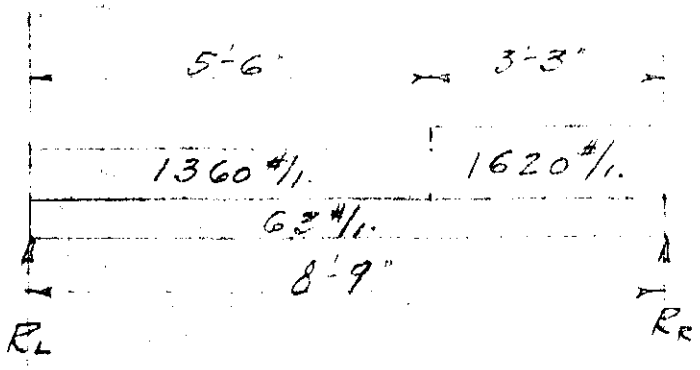
Shear Diagram.



Subject: Meadow Hill Pumping Station
Computation: Engine Room Floor.
Computed by: E.M.V. Checked by: [illegible] Date: May 2, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10523

Beam "B4".



$R_L = 1423 + 4.37 + \frac{260 \times 3.25}{8.75} \times 1.63 = 6400^{\#}$

$R_R = 6900^{\#}$

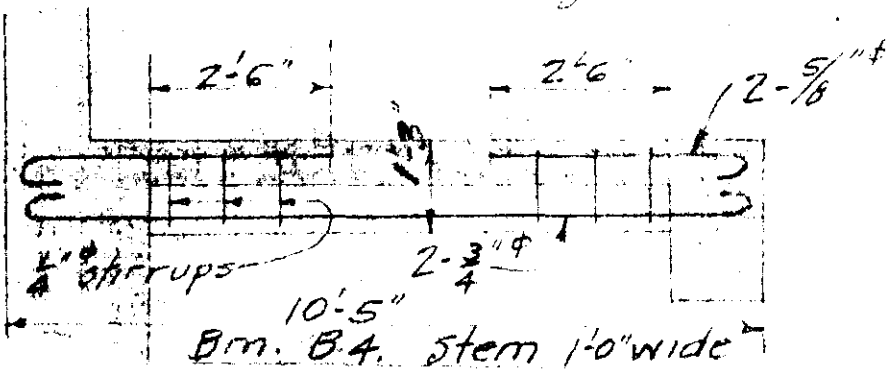
$M = 6400 \times \frac{4.5}{2} = 14{,}400'^{\#}$. $d = \sqrt{\frac{14400}{123}} = 10.9''$

Make beam 1'-3" deep, $d = 12.5''$

Unit shear $= \frac{6900}{12 \times \frac{7}{8} \times 12.5} = 53\ \#/\square''$ O.K.

$A_s = \frac{14400 \times 12}{\frac{7}{8} \times 12.5 \times 18000} = 0.88\ \square''$. Use $2 - \frac{3}{4}''\phi = 0.44 = 0.88\ \square''$.

Bond stress $= \frac{6900}{2 \times 2.36 \times \frac{7}{8} \times 12.5} = 134\ \#/\square$ O.K.



Bm. B4. Stem 1'-0" wide

WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.
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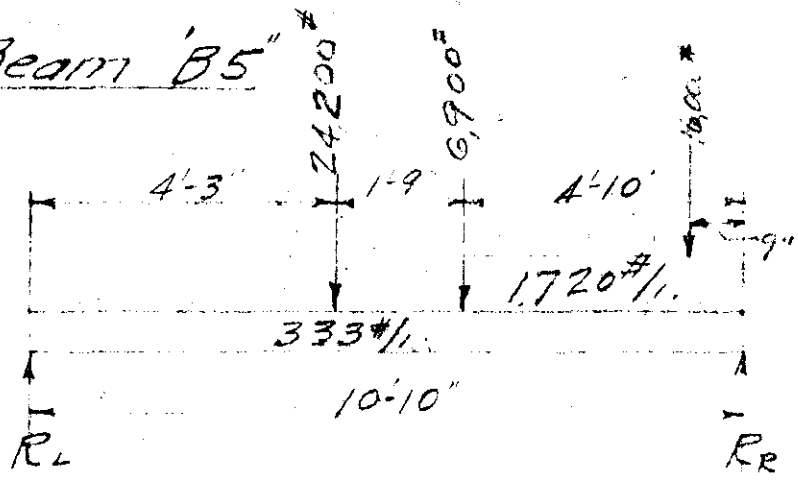
Subject: Meadow Hill Pumping Station
Computation: Engine Room Floor
Computed by: E.M.V. Checked by: [illegible] Date: May 2, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10523

Beam "B5"



Note: Beam redesigned to include [illegible] #/ft [illegible] discharge [illegible] from beam at place of support. Only stirrup design assumed to [illegible].

R_L = 6,900 × 4.83 = 33,300

24,200 × 6.58 = 159,000

1720 × 4.83 × 2.42 = 20,100

Total = 212,400

$R_L = \frac{212,400}{10.83} + 333 \times 5.42 = 21,400^{\#}$

$R_R = 21,600^{\#} + 16,000 = 37,600^{\#}$ (see note above)

$M = 21,400 \times 4.25 - 333\left(\frac{4.25}{2}\right)^2 = 88,000^{\#}$

$"d" = \sqrt{\frac{88,000 \times 12}{123 \times 16}} = 23.1"$

Make bm. 2'-3" deep; "d" = 24.5"

Unit shear = $\frac{\overset{37,600}{\cancel{21,600}}}{16 \times \frac{7}{8} \times 24.5} = \overset{110}{\cancel{63}}$ #/□" O.K.

$A_s = \frac{88,000 \times 12}{\frac{7}{8} \times 24.5 \times 18000} = 2.74^{\square"}$ Use $\left.\begin{matrix} 2-1"\phi \\ 2-\frac{7}{8}"\phi \end{matrix}\right\} = 2.76^{\square"}$

Bond: $u = \frac{37,600}{11.78 \times \frac{7}{8} \times 24.5} = 150$ #/□" O.K. with special [illegible]

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

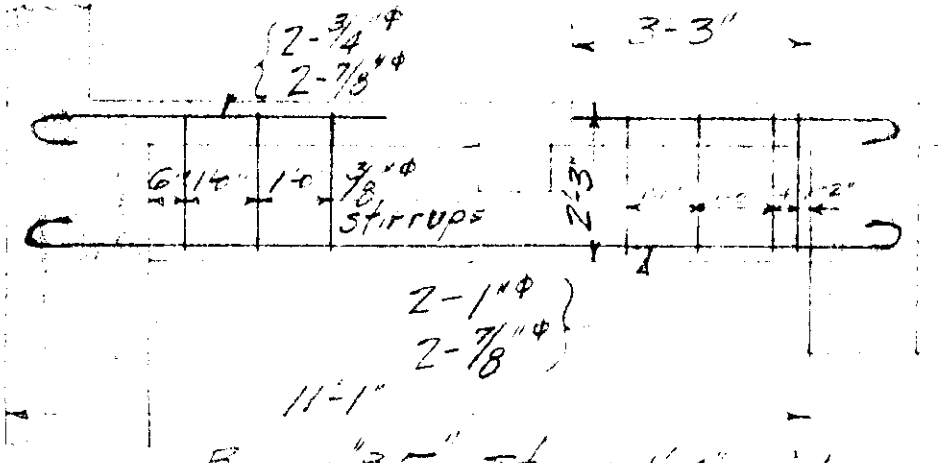
Subject Meadow Hill Pumping Station

Computation Engine Room Floor

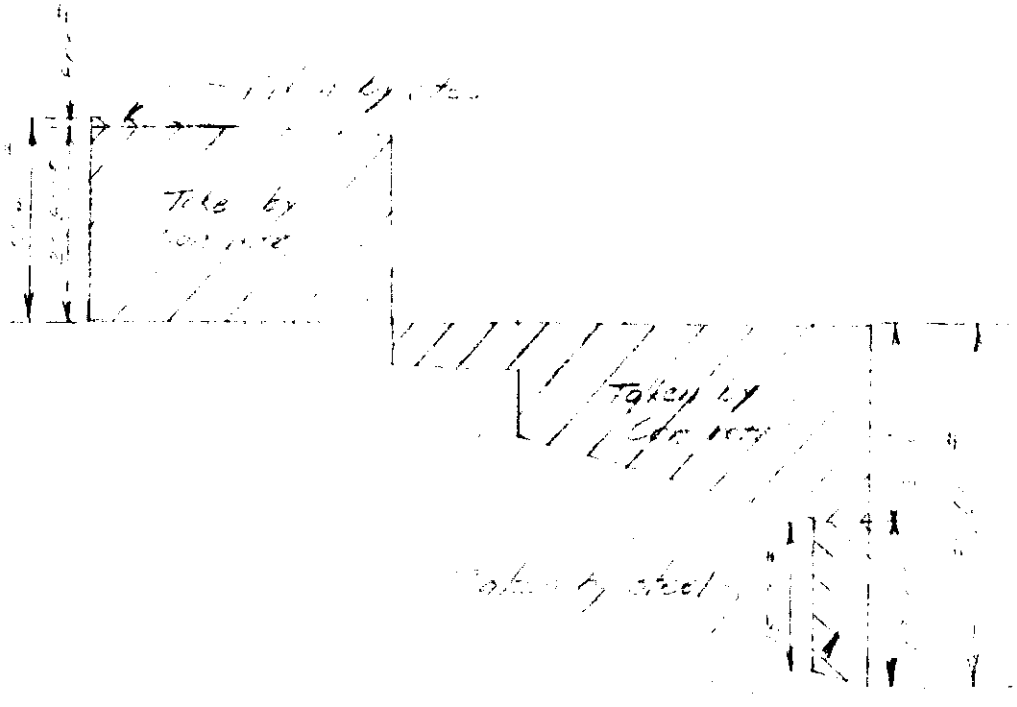
Computed by E.M.V. **Checked by** **Date**

U. S. GOVERNMENT PRINTING OFFICE 10028

Beam B5" (Continued from sheet #14)



Beam "B5" Stem 1'-4" wide



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

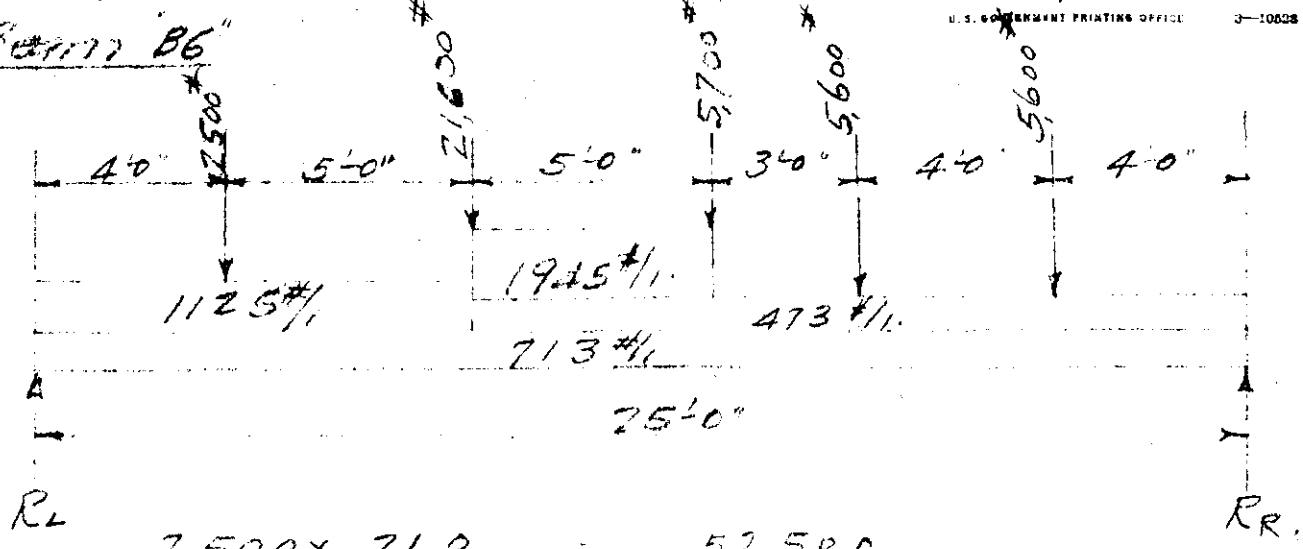
Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.V. **Checked by** [illegible] **Date** May 2, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10028

Beam B6"



2,500 × 21.0	=	52,500
5600 × 2 × 6.0	=	67,200
5700 × 11.0	=	62,700
21,600 × 16.0	=	346,000
1945 × 5.0 × 13.5	=	131,200
1125 × 9.5 × 20.5	=	208000
473 × 16.0 × 5.0	=	60,500
		928,100

$R_L = \frac{928,100}{25.0} + 713 \times 12.5 = 46,000\#$

$R_R = 40\ 200\#$

$M = 46,000 \times 11.0 - 1838 \times 9.0 \times 6.5 - 3131 \times \frac{3.0}{2} - 21,600 \times 2.0$
$- 2500 \times 7.0 = 331,700\#$

Effective depth reqd $= \sqrt{\frac{331,700 \times 12}{123 \times 18}} = 42.4"$ when T-beam action is neglected

Subject: Meadow Hill Pumping Station

Computation: Engine Room Floor

Computed by: E.M.V. Checked by: [illegible] Date: May 3, 1921

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Beam '86' (Continued from sheet #10)

Taking T-beam action into account and assuming that $d = 42.4''$ $\frac{t}{d} = \frac{7}{42.4} = 0.165$, $K = 93$, $b = 24''$

then $d = \sqrt{\frac{331{,}700 \times 12}{93 \times 24}} = 38.5''$

With $d = 42.4$ $A_s = \frac{331{,}700 \times 12}{\frac{7}{8} \times 42.4 \times 18{,}000} = 5.96\ \square''$

Try $4-1\frac{1}{4}''\square$ bars

Unit bond stress $= \frac{46{,}000}{4 \times 5.0 \times \frac{7}{8} \times 42.4} = 62\ \#/\square''$

Pt. to bend up $2-1\frac{1}{4}''\square$ bars –

$46{,}000x - 1838\frac{x^2}{2} = 165{,}800$

$46{,}000x - 919x^2 - 165{,}800 = 0$

$x^2 - 50x + 181 = 0$

$x = 50 \pm \sqrt{\frac{2500 - 724}{2}} = 3.9'$

$40{,}200x - 1186\frac{x^2}{2} = 165{,}800$

$40{,}200x - 593x^2 - 165{,}800 = 0$

$x^2 - 68 + 279 = 0$

$x = \frac{68 \pm \sqrt{4620 - 1116}}{2} = 4.4'$

Unit shear $= \frac{46{,}000}{18 \times \frac{7}{8} \times 42.4} = 69\ \#/\square''$ No stirrups reqd. Use special anch.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

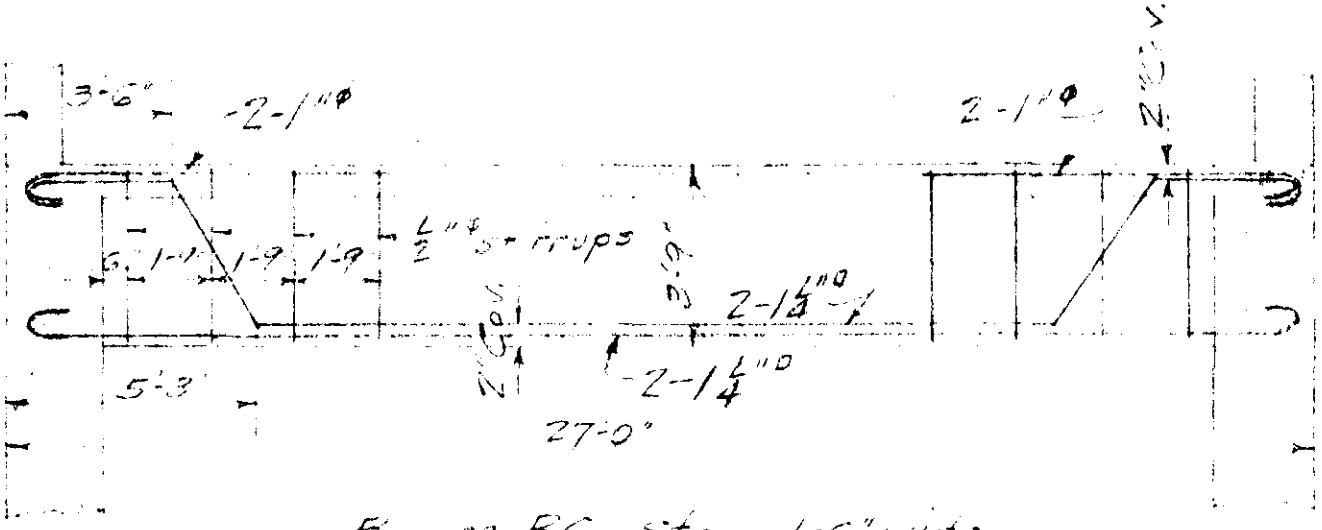
Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.V. **Checked by** ... **Date** May 5, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10593

Beam "B6" (Continues from sheet #17)



Beam B6. Stem 1'-6" wide

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

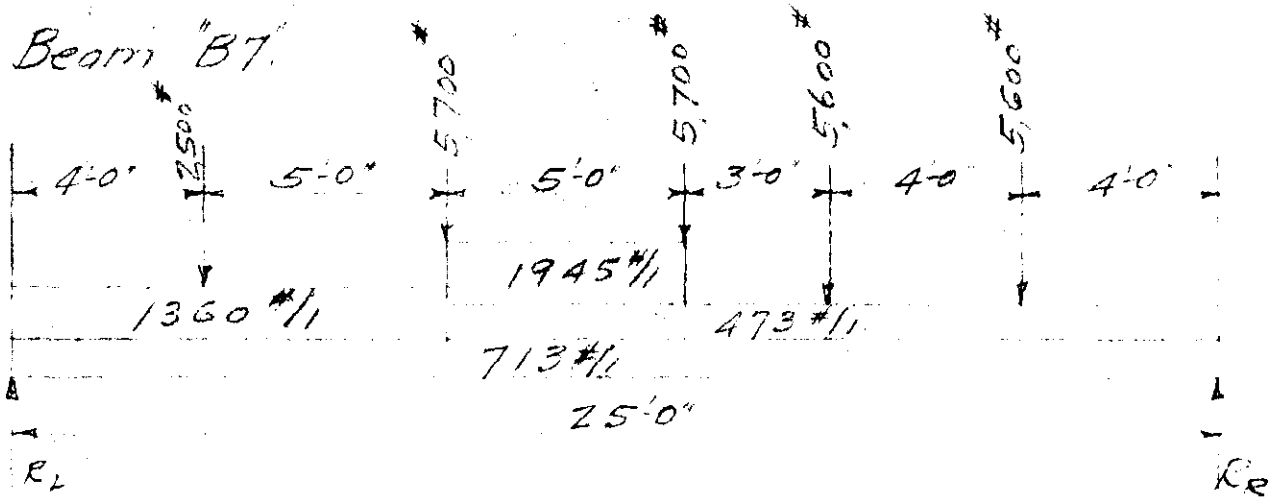
Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.V. **Checked by** W.J.J. **Date** May 3, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10588

Beam "B7"



R_L - $2 \times 5600 \times 6.0 = 67200$

$2 \times 5700 \times 13.5 = 154,000$

$2500 \times 21.0 = 52,500$

$473 \times 16.0 \times 8.0 = 60,500$

$1,945 \times 5.0 \times 13.5 = 131,000$

$1,360 \times 9.0 \times 20.5 = 250500$

$713 \times 25.0 \times 12.5 = 222,500$

$938,200$

$R_L = \frac{938,200}{25.0} = 37,500^{\#}$

$R_R = 34,900^{\#}$

$M = 37500 \times 13.0 - 2500 \times 9.0 - 5700 \times 4.0 - 1945 \times 4.0 \times 2.0$

$- 1360 \times 9.0 \times 8.5 - 713 \times 13.0 \times 6.5$

$= 262,900'\#$

$d'' = \sqrt{\frac{262,900 \times 12}{123 \times 18}} = 37.8''$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.V. Checked by [illegible] Date May 5, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10536

Beam "B7" (Continued from sheet #19)

Make bm. 3'-6" deep, d = 39.5"

Unit shear = $\frac{37,500}{18 \times \frac{7}{8} \times 39.5}$ = 60#/□" O.K. No stirrups reqd.

$A_s = \frac{262,700 \times 12}{\frac{7}{8} \times 39.5 \times 18000}$ = 5.07□" Try 4-1 1/8"□ bars = 5.04□"

With 2-bars bent up bond stress = $\frac{37,500}{2 \times 4.5 \times \frac{7}{8} \times 39.5}$ = 120#/□" O.K.

Point for bending up 2-bars at R_L -

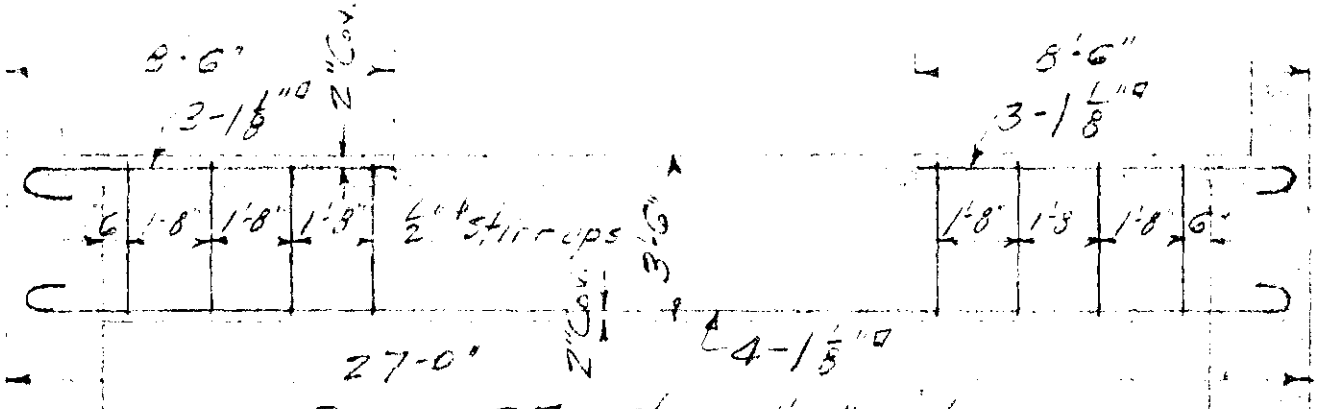
$37,500x - 2073\frac{x^2}{2} - 131,500 = 0$

$x^2 - 36x + 127 = 0$, $x = 4.0'$

Point for bending up 2-bars at R_E -

$34,900x - 1186\frac{x^2}{2} - 131,500 = 0$

$x^2 - 59x + 221 = 0$, $x = 4.0'$



Beam B7. Stem 1'-6" wide

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

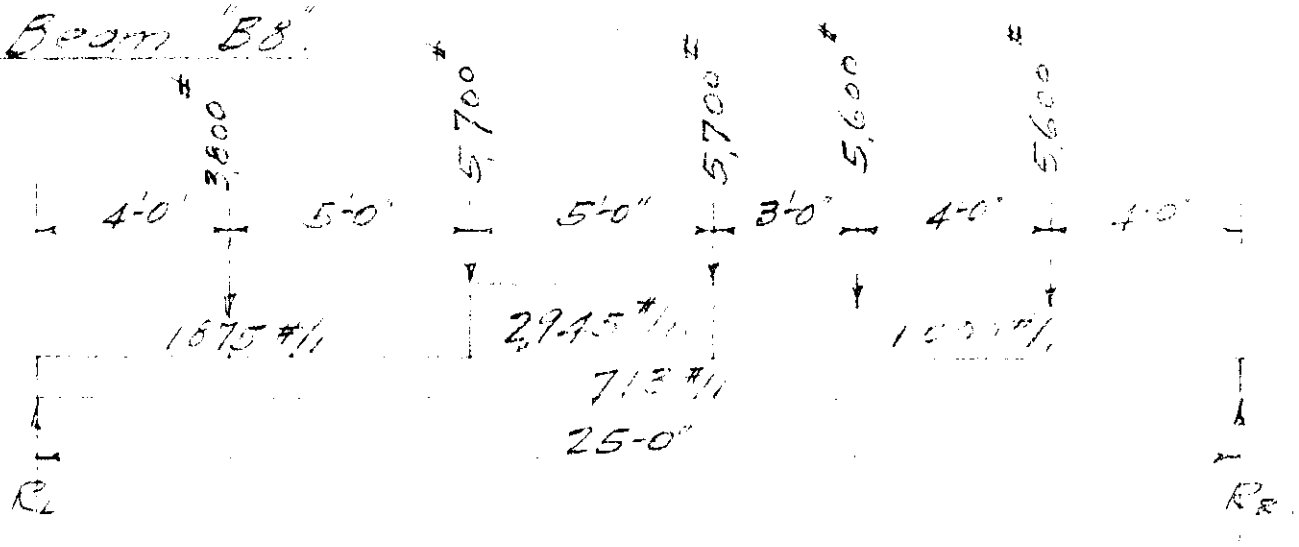
Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.V. **Checked by** [illegible] **Date** May 5, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10588

Beam "B8"



R_L - 2 × 5600 × 6.0 = 67,200

2 × 5700 × 13.5 = 154,000

3,800 × 21.0 = 79,700

1000 × 11.0 × 5.5 = 60,500

2,945 × 5.0 × 13.5 = 198,500

1,875 × 9.0 × 20.5 = 346,000

713 × 25.0 × 12.5 = 222,500

1,128,400

$R_L = \frac{1,128,400}{25.0} = 45,200^{\#}$

$R_R = 41,600^{\#}$

$M = 45,200 \times 12.3 - 3800 \times 8.3 - 5700 \times 3.3 - 1875 \times 9.0 \times 7.8$

$- 2,945 \times 3.3 \times 1.7 - 713 \times 12.3 - 6.2$

$= 307,400'^{\#}$

(303,000) (in [illegible])

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject ... Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.N. Checked by [illegible] Date May 6, 1941

U. S. GOVERNMENT PRINTING OFFICE 3-10528

(Continued from sheet #21)

Assume "d" = 42.4", t = 7" ; $\frac{t}{d} = \frac{7}{42.4} = 0.165$, K = 93;

b = 41"

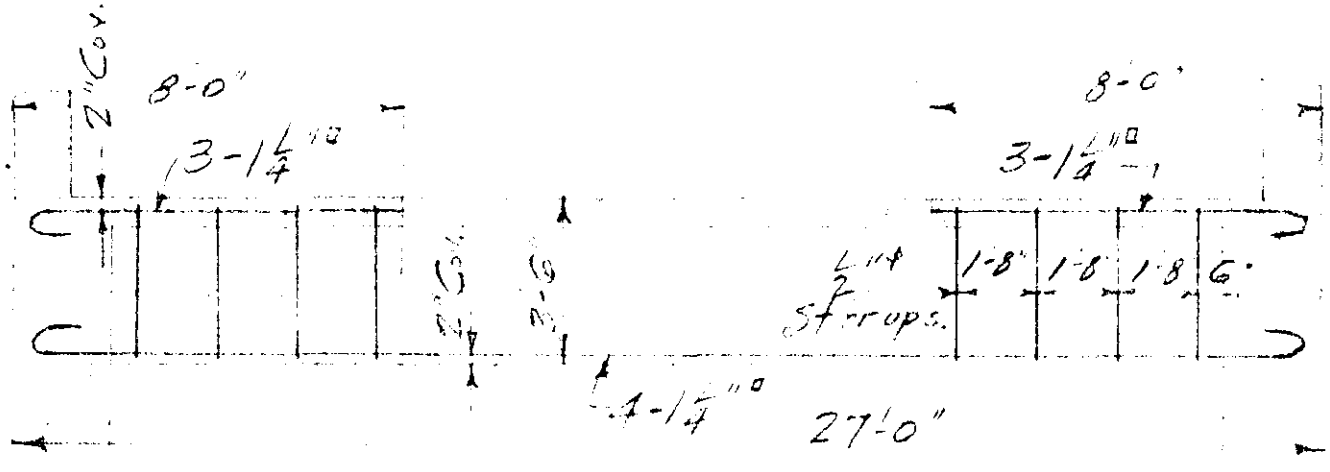
$$d = \sqrt{\frac{307,400 \times 12}{93 \times 41}} = 31.1"$$

Make bm. 3'-6" deep d" = 39.4"

Unit shear = $\frac{45,200}{18 \times \frac{7}{8} \times 39.4} = 72.8$ #/□" C.K.

$$A_s = \frac{307,400 \times 12}{\frac{7}{8} \times 39.4 \times 18,000} = 5.93\square" \quad \text{Use } 4\text{-}1\tfrac{1}{4}\square" = 1.56\square" = 6.24\square"$$

Unit bond = $\frac{45,200}{4 \times 5.0 \times \frac{7}{8} \times 39.4} = 66$ #/□" C.K.



Beam B.B. Stem 1'-6" wide.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

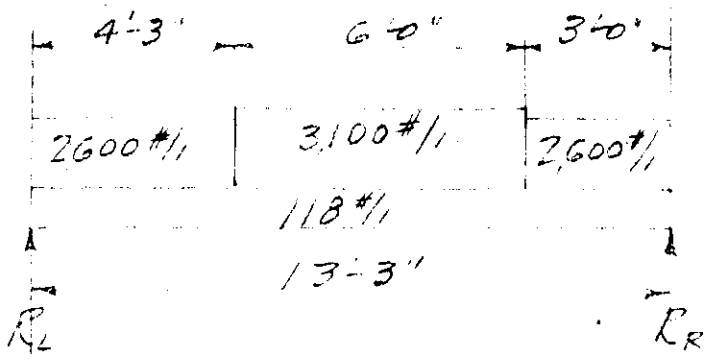
Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.V. **Checked by** [illegible] **Date** May 6, 1921.

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Beam "B9"



$R_L = 19,300^{\#}$

$R_R = 17,500^{\#}$

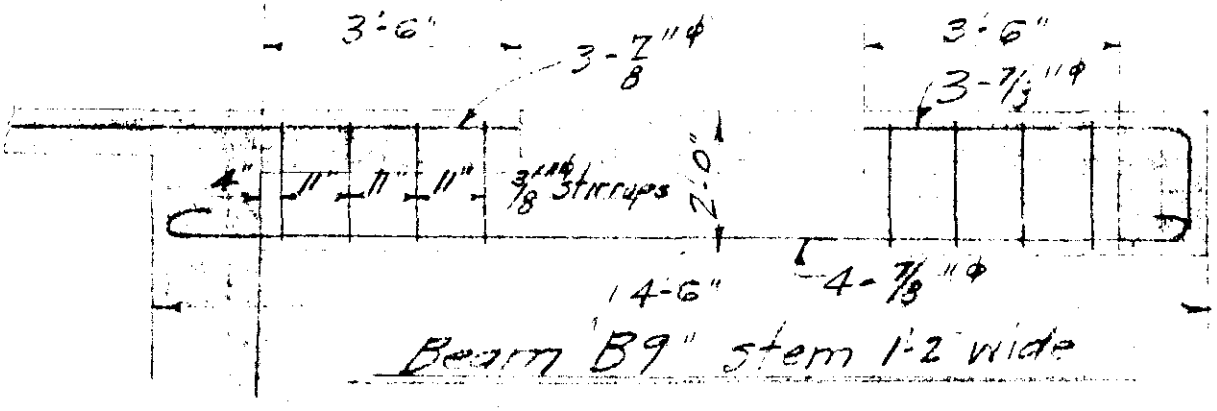
$M = 19,300 \times 6.7 - 2718\frac{(6.7)^2}{2} - 500\frac{(3.4)^2}{2} = 65,800.\#$

$d = \sqrt{\frac{65,800 \times 12}{123 \times 26}} = 15.7''$

Make bm. 2'-0" deep, $d'' = 21.5$

Unit shear $= \frac{19,500}{14 + \frac{7}{3} \times 21.5} = 74\ \#/\square''$ O.K.

$A_s = \frac{65800 \times 12}{\frac{7}{8} \times 21.5 \times 18000} = 2.33\square''$ $4 - \frac{7}{8}''\phi = 2.40\square''$



Beam "B9" stem 1'-2" wide

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

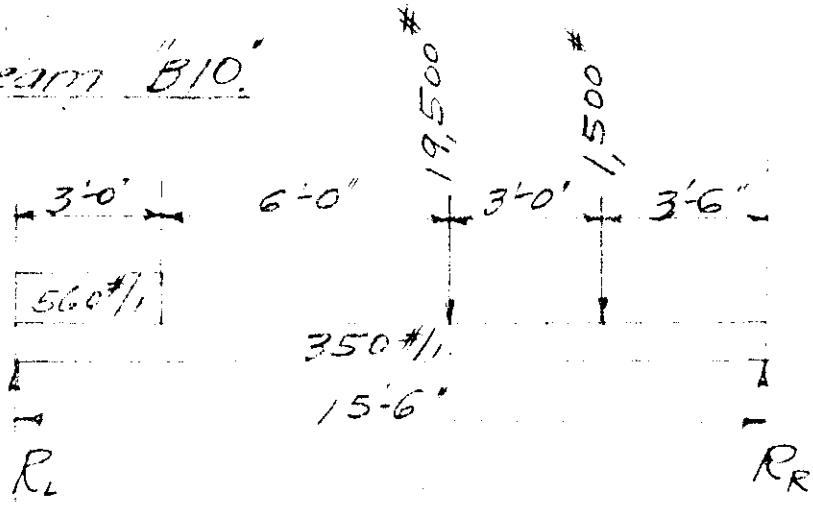
Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.V. **Checked by** [illegible] **Date** May 6, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Beam "B10"



$R_L = \frac{1500 \times 3.5 + 19500 \times 6.5 + 560 \times 3.0 \times 14.0 + 350 \times 7.75}{15.5}$

$= 12,300^{\#}$

$R_R = 15,500^{\#}$

$M = 15,500 \times 3.5 - 1500 \times 3.0 - 350 \times 6.5 \times 3.25 = 85,700'^{\#}$

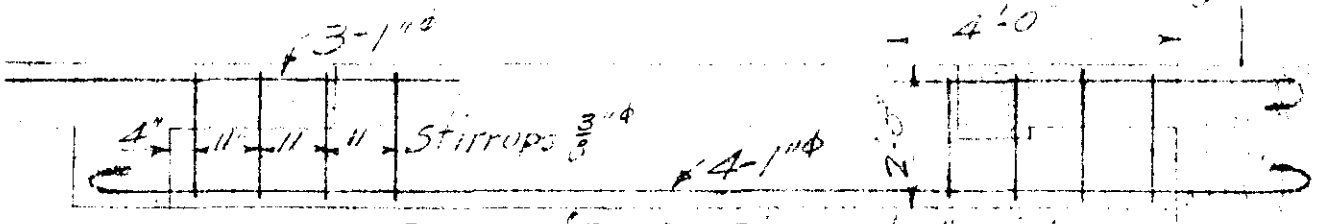
$d = \sqrt{\frac{85,700 \times 12}{123 \times 26}} = 18.3"$

Make b.m. 2'-0" deep, d = 21.5"

Unit shear $= \frac{15,500}{14 \times \frac{7}{8} \times 21.5} = 56.8^{\#}/\square'$ O.K.

$A_s = \frac{85,700 \times 12}{\frac{7}{8} \times 21.5 \times 18,000} = 3.14^{\square} = 4\text{-}1''\phi$ bars.

With 2-bars bent up unit bond $= \frac{15,500}{2 \times 3.14 \times \frac{7}{8} \times 21.5} = 131^{\#}/\square''$ O.K.



Beam B10. Stem 1'-2" wide.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

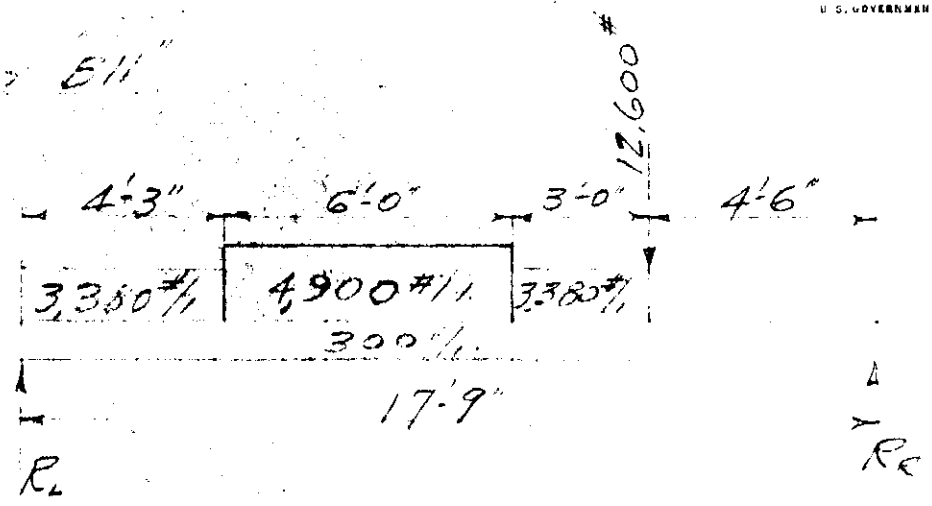
Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.V. **Checked by** [illegible] **Date** May 7, 1941

U. S. GOVERNMENT PRINTING OFFICE 3-10528

Beam E11"



R_L - 12,600 × 4.5 = 56,700

3,380 × 3.0 × 6.0 = 60,900

4,900 × 6.0 × 10.5 = 309,000

3,380 × 4.25 × 15.6 = 224,000

300 × 17.75 × 8.87 = 47,200

697,800

$R_L = \frac{697,800}{17.75} = 39,300^{\#}$

$R_R = 32,500^{\#}$

$M = 39,300 \times 8.8 - 3650 \times 4.25 \times 6.68 - 5200 \times \frac{4.55}{2}$

$= 187,700$

Assuming T-bm. action $d = \sqrt{\frac{187,700 \times 12}{123 \times 48}} = 19.5''$

Try bm. 2'-0" deep, $d = 21.5''$

$A_s = \frac{187,700 \times 12}{\frac{7}{8} \times 21.5 \times 18,000} = 6.66''$

Subject: Meadow Hill Pumping Station
Computation: Engine Room Floor
Computed by: E.M.V. Checked by: [illegible] Date: May 7, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10638

Beam "B11" (Continued from sheet #25)

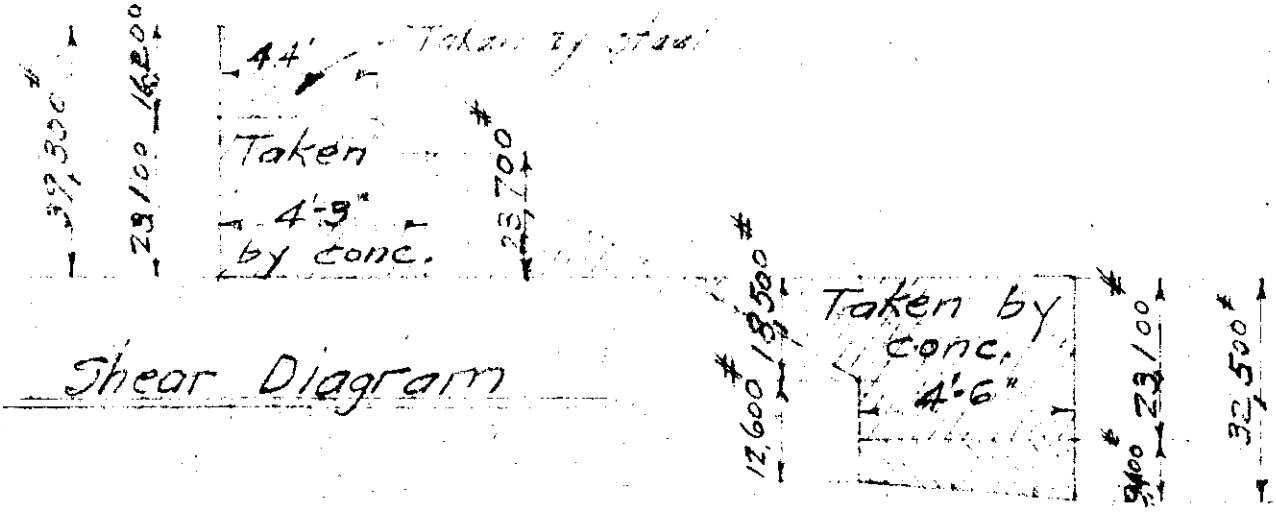
Make bm. 2'-3" deep; d = 24.5"

$$A_s = \frac{187{,}700 \times 12}{\frac{7}{8} \times 24.5 \times 18{,}000} = 5.54\,\square'' = 4\text{-}1\tfrac{1}{4}''\square\ @\ 1.56\,\square'' = 6.24\,\square''$$

With 2-1"□ bars bent up unit bond stress

$$= \frac{39{,}300}{2 \times 4.5 \times \frac{7}{8} \times 24.5} = 204\ \#/\square'.$$ No bars bent up

$$\text{Unit shear} = \frac{39{,}300}{18 \times \frac{7}{8} \times 24.5} = 102.\ \#/\square'.$$ Stirrups req'd.



Shear Diagram

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Engine Room Floor

Computed by E.M.Y. **Checked by** [illegible] **Date** May 7, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

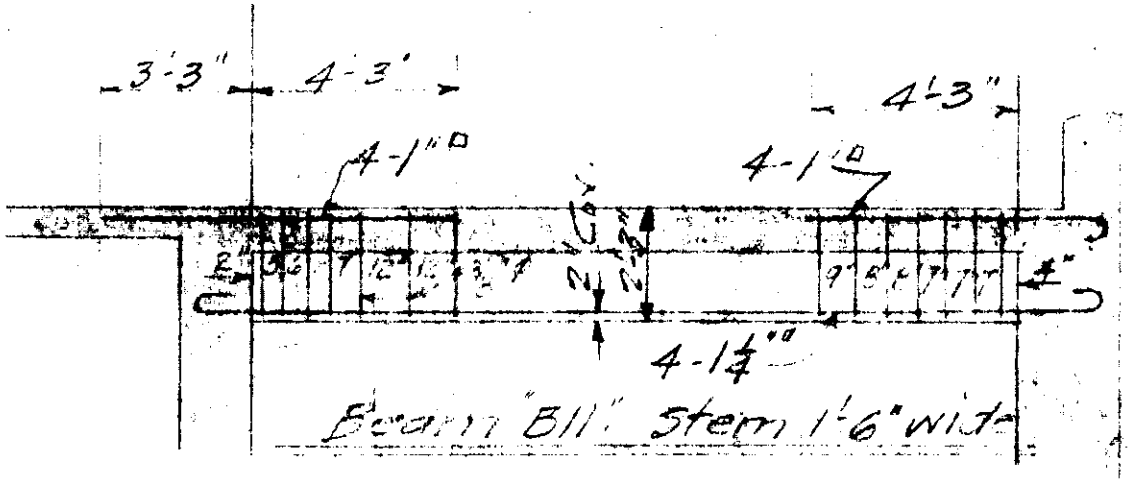
Beam "B11" (Continued from sheet #26)

No. of $\frac{3}{8}$" ϕ stirrups at R_L = $\frac{6100 \times 53}{0.22 \times 16000 \times \frac{7}{8} \times 24.5}$ = 6.

" " " " " R_R = $\frac{8,700 \times 54}{0.22 \times 16,000 \times \frac{7}{8} \times 24.5}$ = 7.

At R_L space stirrups 2", then 5", 6", 6", 7", 12", & 12"

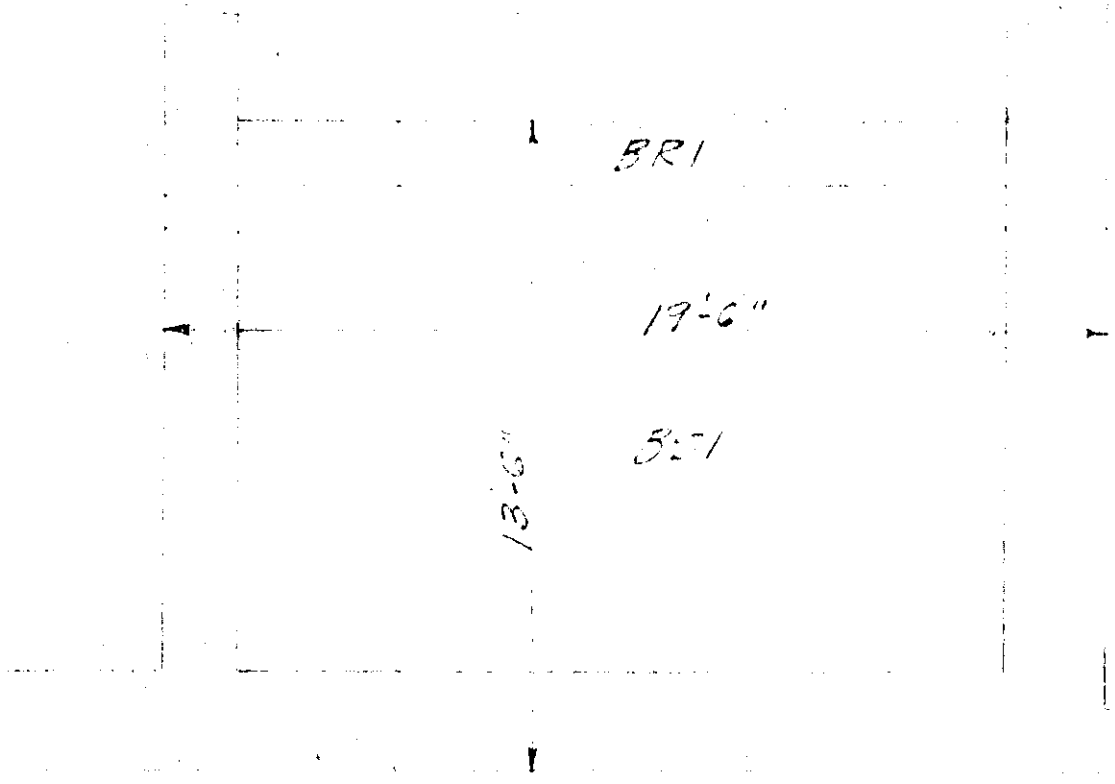
At R_R " " 4", then 7", 7", 7", 8", 8", & 7"



Beam "B11" Stem 1'-6" wide

Subject: Meadow Hill Pumping Station
Computation: Boiler Room Floor
Computed by: E. M. V. Checked by: [illegible] Date: May 8 1931

U. S. GOVERNMENT PRINTING OFFICE



Plan of Boiler Room Floor

Slab BS1

Assumed Live Load = 100 #/□'

" D.L. slab = 75

Total 175 #/□'

Max. pos. mom. = $\frac{9}{128} \times 175 (11.0)^2 = 1500$ '#

" neg. " = $\frac{1}{8} \times 175 \times 121 = 2600$ '#

" shear = $\frac{5}{8} \times 175 \times 11.0 = 1200$ #

Effective depth = $\sqrt{\frac{2600}{147}} = 4.2$"

Unit shear = $\frac{1200}{12 \times \frac{7}{8} \times 4.2} = 28$ #/□" O.K.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 3[illegible]

Subject Meadow Hill Pumping Station

Computation Boiler Room Floor

Computed by E.M.V. **Checked by** [illegible] **Date** May 8, 1941.

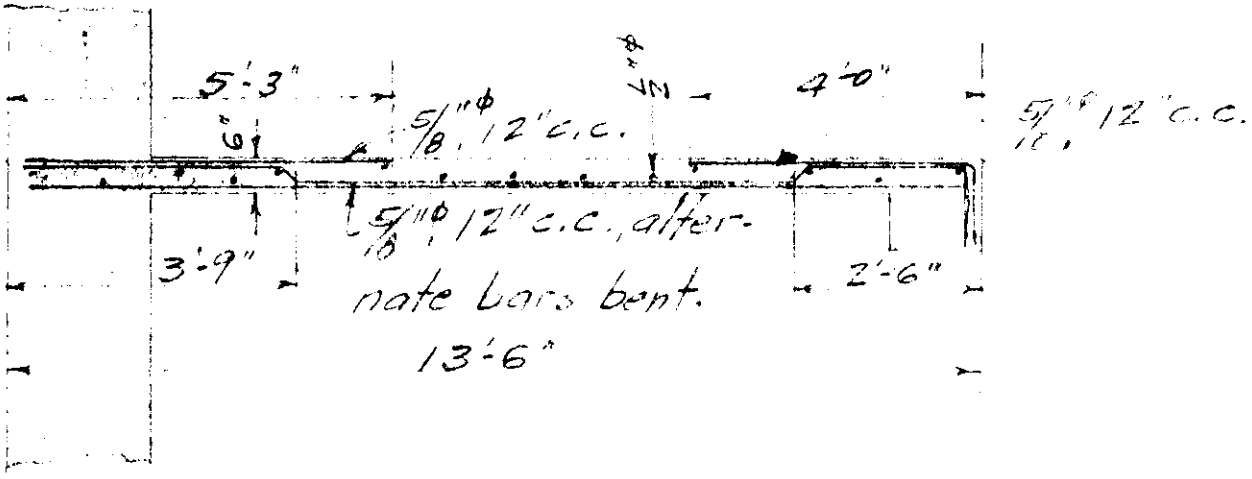
U. S. GOVERNMENT PRINTING OFFICE 3-10628

Slab "BS1" (Continued from sheet #28)

A_s for pos. mom. = $\dfrac{1500 \times 12}{\frac{7}{8} \times 4.2 \times 18{,}000} = 0.28^{\square'} = \frac{5}{8}''\phi$, 12" c.c.

" " neg. " = $\dfrac{2600 \times 12}{\frac{7}{8} \times 4.2 \times 18000} = 0.47^{\square''} = \frac{5}{8}''\phi$, 8" c.c.

Bond stress = $\dfrac{1200}{1.5 \times 1.96 \times \frac{7}{8} \times 4.2} = 111\#/\square''$ O.K.



Subject Meadow Hill Pumping Station

Computation Boiler Room Floor

Computed by E. M. V. **Checked by** [illegible] **Date** May 6, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10628

Beam "BR1"

Effective span = 17'-9"

Load from slab = $\frac{3}{8} \times 175 \times 11.0 =$ 720 #/.

Beam say 180

Total = 900 #/.

$M = \frac{1}{8} \times 900 \times (17.75)^2 = 35{,}400$ #

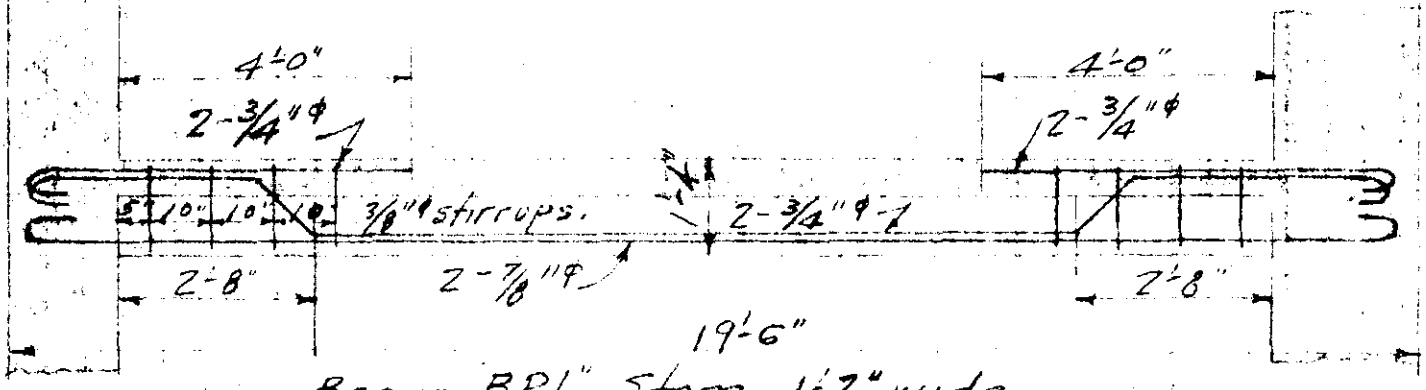
$d = \sqrt{\frac{35{,}400 \times 12}{123 \times 14}} = 15.7"$ Make bm. 1'-4" deep, d = 13.5"

Unit shear = $\frac{900 \times 8.0}{14 \times \frac{7}{8} \times 13.5} = 44$ #/□". O.K.

$A_s = \frac{35{,}400 \times 12}{\frac{7}{8} \times 13.5 \times 18{,}000} = 2.00$ □" Use 2-$\frac{3}{4}$"φ @ 0.44 = 0.88 □"

2-$\frac{7}{8}$"φ @ 0.60 = 1.20

Total = 2.08 □".



Beam BR1. Stem 1'-2" wide.

WAR DEPARTMENT

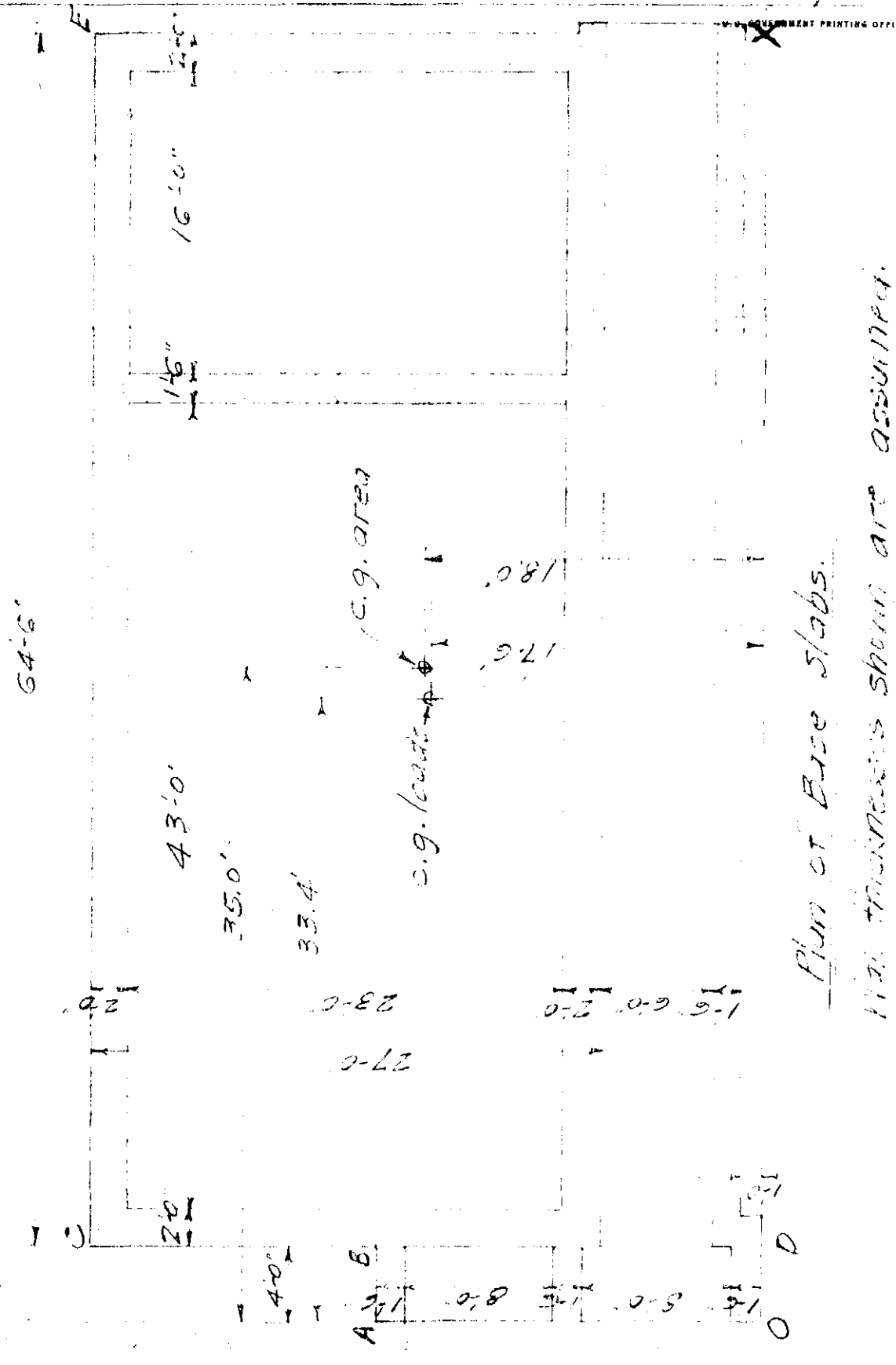
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Weight & Center of Gravity

Computed by E.M.Y. **Checked by** W.H.E. **Date** May 5, 1941

U.S. GOVERNMENT PRINTING OFFICE 3—10598



Plan of Base Slabs.

H.P. thickness shown are assumed.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Weight & Center of Gravity

Computed by E.M.V. **Checked by** W. W. Z. **Date** May 3, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10828

Description	Dimensions & Unit Weight	Weight in Kips	Arm Y	Moment Abt X-Axis	Arm X	Moment Abt Y-Axis
Roofing	25.0 × 62.5 × 6	9.4	22.0	198.	36.3	[illegible]
Roof fill	25.0 × 62.5 × 0.33 × 90	46.8	22.0	1,020.	36.3	[illegible]
Roof slab	25.0 × 62.5 × 0.42 × 150	98.5	22.0	2,160.	36.3	3,580
Roof bms.	2 × 25.2 × 64.0	3.2	22.0	71.	51.1	104
	2 × 24.5 × 58.0	2.9	22.0	64.	23.8	69
	1 × 24.5 × 45.0	1.1	22.0	24.	23.8	26.
	2 × 23.8 × 35.0	1.7	22.0	37.	36.3	62
	2 × 68.0 × 17	2.2	22.0	49.	36.3	80.
	2 × 10.0 × 17	0.4	22.0	9.	36.3	15.
Col. fireproofg	5 × 1.33 × 1.0 × 150	1.0	22.0	22.	34.9	35
	2 × 0.7 × 0.8 × 150	0.2	22.0	4.	36.3	7.
Crane bms.	2 × 33 × 63	4.2	22.0	92.	36.3	152
Crane rails	2 × 30 × 21	1.3	22.0	29.	36.3	47
Crane cols.	2 × 33 × 18	1.2	34.9	42.	36.3	43
	2 × 21 × 18	1.1	9.3	10.	36.3	40
	4 × 41 × 18	3.5	22.0	77.	51.1	179
	2 × 45 × 18	1.6	22.0	35.	23.8	38
	1 × 49 × 18	0.9	22.0	20.	22.8	33
	3 × 41 × 18	2.3	17.8	41	20.8	48
		133.0		4,004		6,633
	2 × 35 × 18	1.3	22.0	29.	36.3	47

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Weight & Center of Gravity

Computed by E.M.V. **Checked by** W. W. Z. **Date** May 6, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Description	Dimensions & Unit Weight	Weight in Kips	Arm "Y"	Moment Abt X-Axis	Arm "X"	Moment Abt Y-Axis
Brick walls	2×64.3×21.5×125	346.0	22.0	7,600	36.3	9,100
	2×24.8×21.5×125	133.5	22.0	2,945	36.3	4,852
	1×2.5×16.0×125	3.0	8.5	26	51.1	153
Engine Rm. Slab	23×42×0.6×150	11.0	22.0	2,002	27.5	2500
	16×2.2×0.83×150	45.8	22.0	1,007	58.5	2,680
Floor Grm. B3	1.7×1.3×14.7×150	4.9	26.3	129	7.3	46
B5	1.7×1.3×9.1×150	3.0	18.3	55	10.5	32
B6	1.5×3.2×23×150	16.5	22.0	365	15.8	252
B7 & B8	6×1.5×3.2×23×150	99.3	22.0	2185	31.0	3,080
B9	1.2×1.2×11.5×150	2.5	27.3	72	56.5	141
B10	1.2×1.2×14.0×150	3.0	18.0	54	62.9	189
B11	1.4×1.3×16.0×150	4.4	19.0	84	58.5	257
Conc. walls	1.1×2.5×64.5×2×150	53.1	22.0	1,168	36.3	1,925
	1.1×2.5×24.8×2×150	20.5	22.0	452	36.3	745
	2.0×20.3×46.5×2×150	568.0	22.0	12,500	27.3	15,500
	2×17.7×18.0×2×150	191.0	22.0	4200	59.5	11,380
	2×23×20.3×150	140.0	22.0	3,080	5.0	700
	2×23×17.7×150	122.2	22.0	2690	67.5	8,250
	1.5×23×20.3×150	105.0	22.0	2,310	49.8	5,230
		1953.1		43,918		67,027

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Meadow Hill Pumping Station

Computation: Weight & Center of Gravity

Computed by: E. M. V. Checked by: N. W. Z. Date: May 9, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10523

Description	Dimensions & Unit Weight	Weight in Kips	Arm "Y"	Moment Abt X-Axis	Arm "X"	Moment Abt Y-Axis
Conc. walls	2×1.5×4.0×18×150	32.4	15.0	486.	2.0	65.
	1.5×4.0×17.3×150	15.6	0.8	12.	2.0	31.
Outside slab	1.5×4.0×17.5×150	15.8	10.3	163.	2.0	32.
Base slab	3.3×27×46.5×150	620.0	22.0	13,640.	27.3	16,900.
	3.3×27×18×150	240.0	22.0	5,290.	59.5	14,280.
	3.0×11.0×4.0×150	19.8	15.0	297.	2.0	40
Conduit wall	1.5×15.5×69×150	233.0	1.8	420.	34.5	8,050.
" roof	1.5×6.0×69×150	93.0	5.5	511.	34.5	3,204
" floor	2.0×6.0×69×150	124.2	5.5	684	34.5	4,280.
Earth fill	4×7.5×69×100	476.0	4.8	2,282	34.5	16,400.
Water in sump	11×23×43×62.5	680.0	22.0	14,960.	27.5	18,700
" " cond.	6×12×69×62.5	310.0	5.5	1,705	34.5	10,700.
Gas engines	4×6,000	24.0	28.5	685	26.5	636.
Engine bases	4×6,000	24.0	28.5	685	26.5	636.
Gear units	4×4,000	16.0	21.0	336.	26.5	424
Prop. pumps	4×8,000	32.0	21.0	672	26.5	848.
Gate valves, etc	4×11,000	44.0	14.5	638	29.5	1,298
Vol. pump mot.	1×3,000	3.0	25.0	75	56.3	169
" " base	1×1200	1.2	25.0	30	56.3	68.
		3004.0		43,671		96,761.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Weight & Center of Gravity

Computed by E.M.V. **Checked by** W. W. Z. **Date** May 9, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Description	Dimensions & Unit Weights	Weight in Kips	Arm Y	Moment Abt X-Axis	Arm X	Moment Abt Y-Axis
Standby Unit	1 × 16,000	16.0	25.5	408	49.0	783.
" base	1 × 8,500	8.5	25.5	216.	49.0	416.
Switchboard	1 × 4,000	4.0	16.5	66.	63.0	252.
Crane	1 × 8500	8.5	22.0	187	36.3	308
Boiler	1 × 4,000	4.0	13.5	54	60.5	242
Vol. pump pipg	2 × 2500	5.0	20.5	103	58.5	293
Boiler fms ab	[illegible] × 16. × 0.5 × 150	12.3	15.6	192	58.5	720
" bm	2.3 × 1.3 × 16.0 × 150	7.2	21.3	153	58.5	421
		65.5		1379		3,435
From sheet	#32	183.0		4004		6638.
" "	#33	1953.1		42,718		67[illegible]7.
" "	#34	3004.0		43671		96761
	Totals	5205.6		91,972		173,861.

$$\bar{X} = \frac{173,861}{5,205.6} = 33.4'$$

$$\bar{Y} = \frac{91,972}{5,205.6} = 17.6'$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Stations

Computation Soil Pressures

Computed by E. M. V. **Checked by** W. W. Z. **Date** May 10, 1911.

U. S. GOVERNMENT PRINTING OFFICE 3-10528

Moment of inertia of base area about axis thru c.g. parallel to O-Y.-

$\frac{1}{12} \times 34.5(64.5)^3 + 34.5 \times 64.5(1.25)^2 = 773500'^4$

$\frac{1}{12} \times 20.5(4.0)^3 + 20.5 \times 4.0 \times (33.0)^2 = 69300$

Total = $862800'^4$

Moment of inertia of base area about axis thru c.g. parallel to O-X.-

$\frac{1}{12} \times 64.5(34.5)^3 + 64.5 \times 34.5(0.25)^2 = 228000'^4$

$\frac{1}{12} \times 4.0(20.5)^3 + 4.0 \times 20.5(8.0)^2 = 8300$

Total 228300

Soil pressure at "C" & "A" $= \frac{5205600}{2307} + \frac{5205600 \times 1.6 \times 35.0}{862800}$

$= 2260 + 340 = \underline{2600}^{\#}$

Soil pressure at C, B, & D $= 2,260 + 340 \times \frac{31}{35} = \underline{2500}^{\#}/\square'$

Soil pressures at E & X $= 2,260 - 340 \times \frac{39.5}{35} = \underline{1125}^{\#}/\square'$

WAR DEPARTMENT

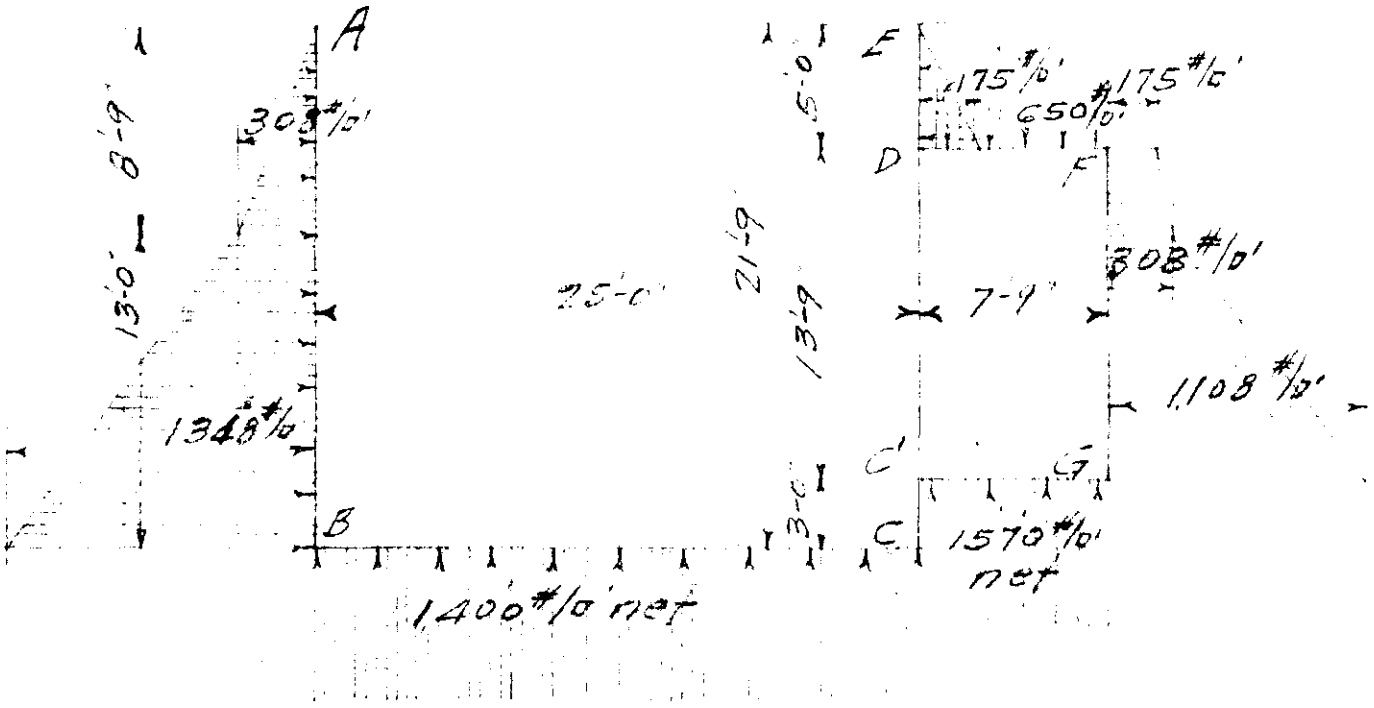
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Transverse Section Thru Wet Pump Room

Computed by E. M. V. **Checked by** [illegible] **Date** May 12, 1940

U. S. GOVERNMENT PRINTING OFFICE 3—10528



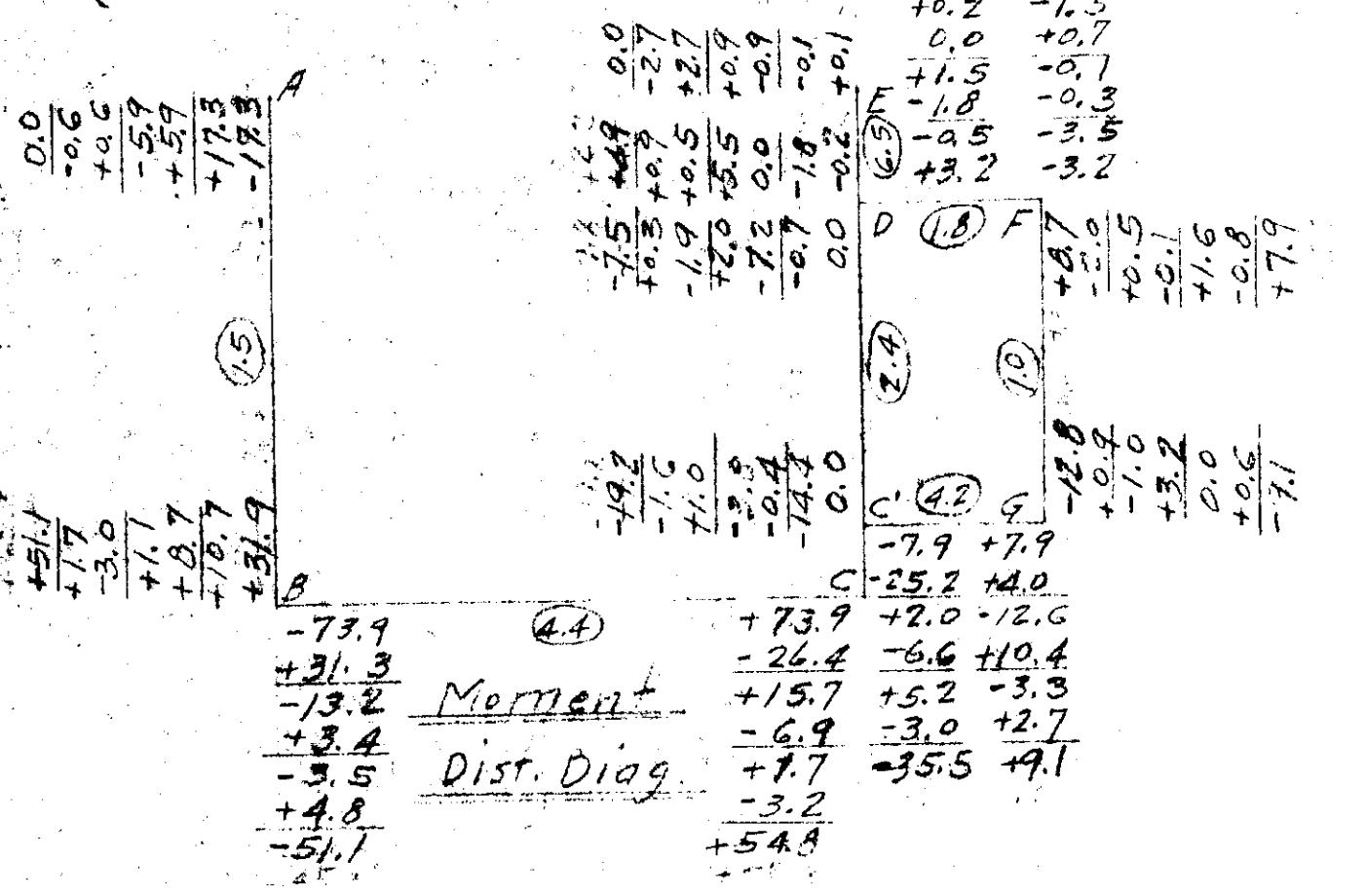
Loading Diagram on Transverse Section in Wet Pump Room.

Subject: Meadow Hill Pumping Station
Computation: Transverse Section Thru Wet Pump Room
Computed by: E.M.V. Checked by: [illegible] Date: May 12, 1931

U. S. GOVERNMENT PRINTING OFFICE 3—10608

(Continued from sheet # 37)

Member	Length	Assumed Thickness	I	$\frac{I}{l}$	K
A-B	261"	24"	13,824 in⁴	53.0	1.5
B-C	300	36"	46,656	155.5	4.4
C'-D	165	24"	13,824	83.8	2.4
D-E	60	24"	13,824	230.5	6.5
D-F	73	18"	5,832	62.8	1.8
F-G	165	18"	5,832	35.3	1.0
G-C'	93	24"	13,824	148.8	4.2



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Transverse Section Thru Wet Pump Room

Computed by E.M.V. **Checked by** **Date** May 15, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3-10528

Continued from sheet # 38)

Member	A-B.	Shear	at	"A" =	1,200
		"	"	"B" =	19,800
"	B-C.	"	"	"B" =	17,400
		"	"	"C" =	17,600
"	C'-D	"	"	"C'" =	1,900
		"	"	"D" =	1,900
"	D-E.	"	"	"D" =	700
		"	"	"E" =	1,100
"	D-F.	"	"	D =	1,800
		"	"	"F" =	3,200
"	F-G.	"	"	"F" =	2,800
		"	"	"G" =	5,200
"	G-C'.	"	"	"G" =	2,700
		"	"	"C'"	9,500

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

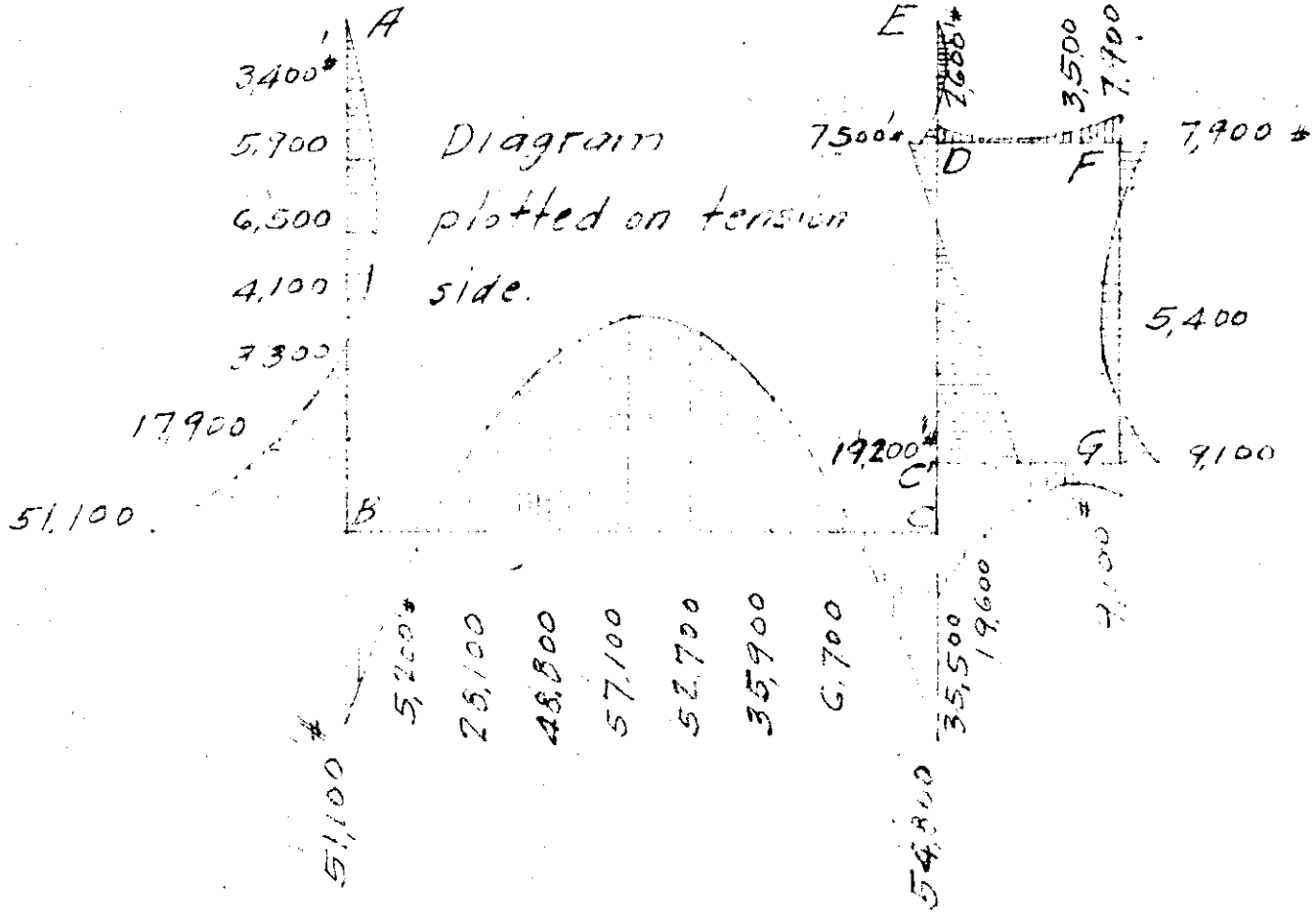
Subject Meadow Hill Pumping Station

Computation Transverse Section Thru Wet Pump Room

Computed by E.M.V. **Checked by** W.J.V. **Date** May 13, 1941

(Continued from sheet # 39)

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Bending Mom. Diagram - No Sidesway

WAR DEPARTMENT

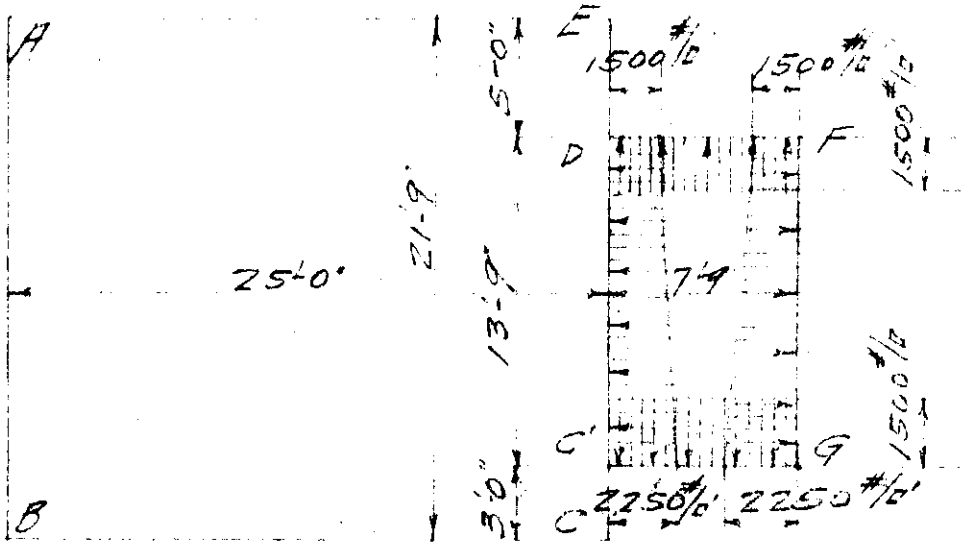
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

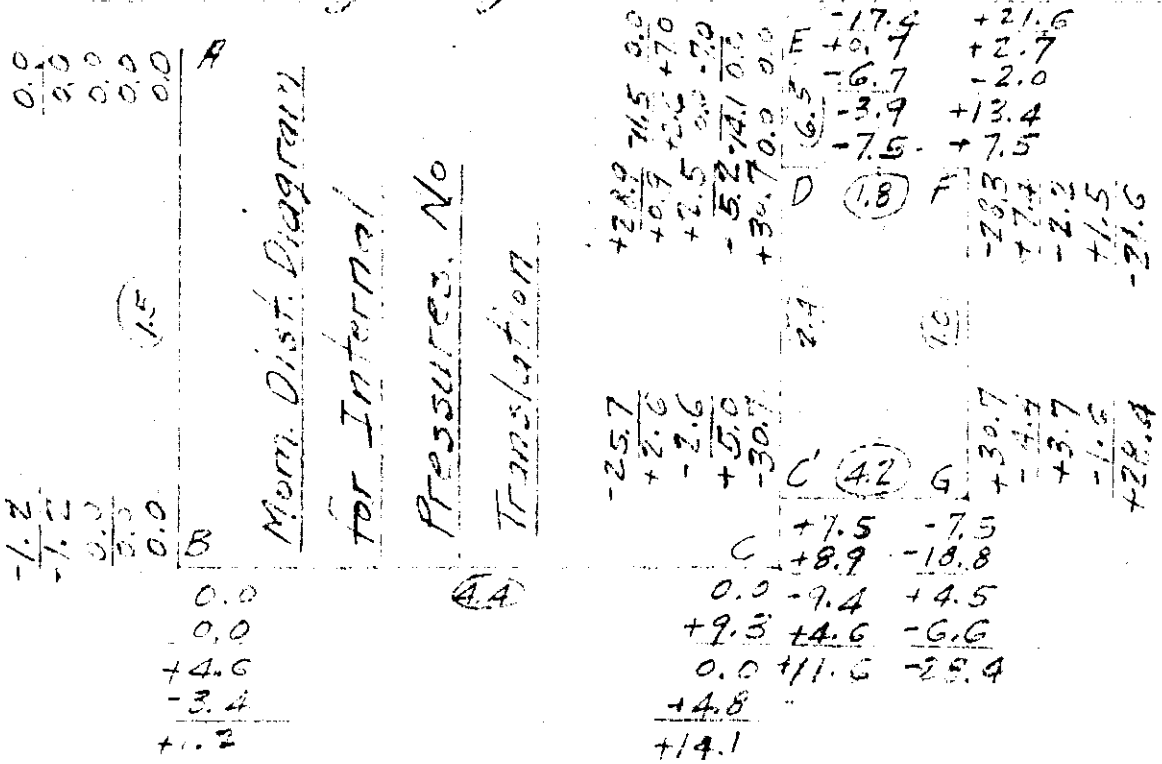
Computation Transverse Section Thru Wet Pump Room

Computed by E. M. V. **Checked by** W. W. Z. **Date** May 15, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Loading Diagram for Internal Pressures



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject Meadow Hill Pumping Station

Computation Transverse Section Thru Wet Pump Room

Computed by E. M. Y. **Checked by** **Date** May 1[illegible]

U. S. GOVERNMENT PRINTING OFFICE 3-10523

(Continued from Sheet #41)

Member B-C Shear at "B" = [illegible]#

" " "C" = [illegible]#

" C-D " "C" = 13,[illegible]

" " "D" = [illegible]

" D-E " "D" = [illegible]

" " "E" = 2,[illegible]

" D-F " "D" = 5,3[illegible]

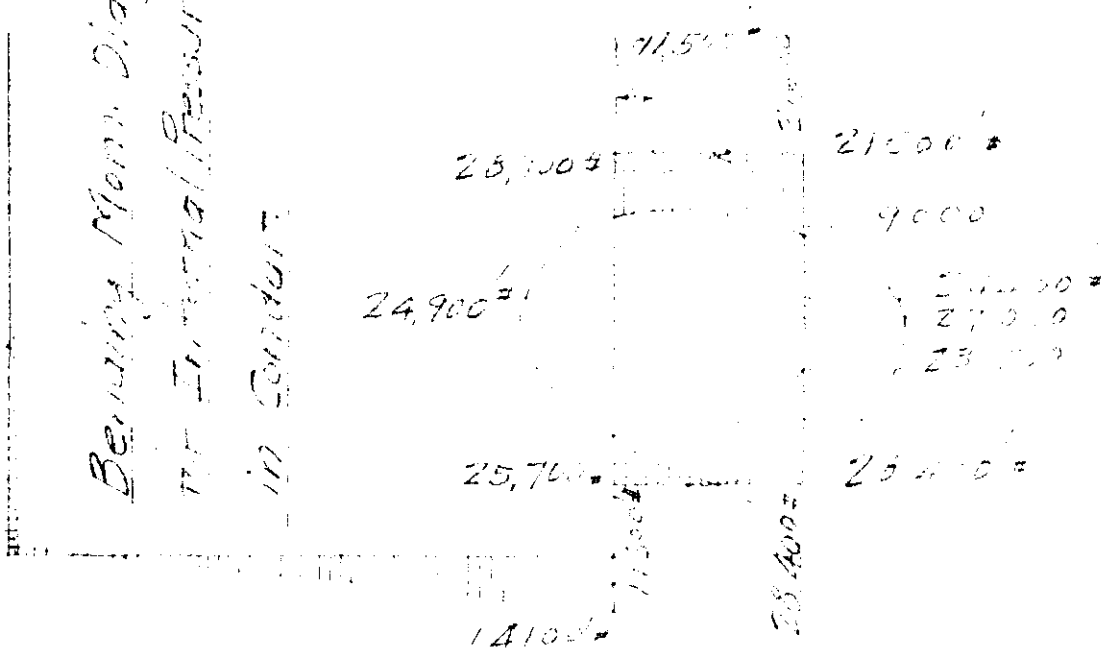
" " "F" = 6,3[illegible]

" C-G " "C" = 5,6[illegible]

" " "G" = 8,[illegible]

" F-G " "F" = 13,[illegible]

" " "G" = 13,[illegible]



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 14

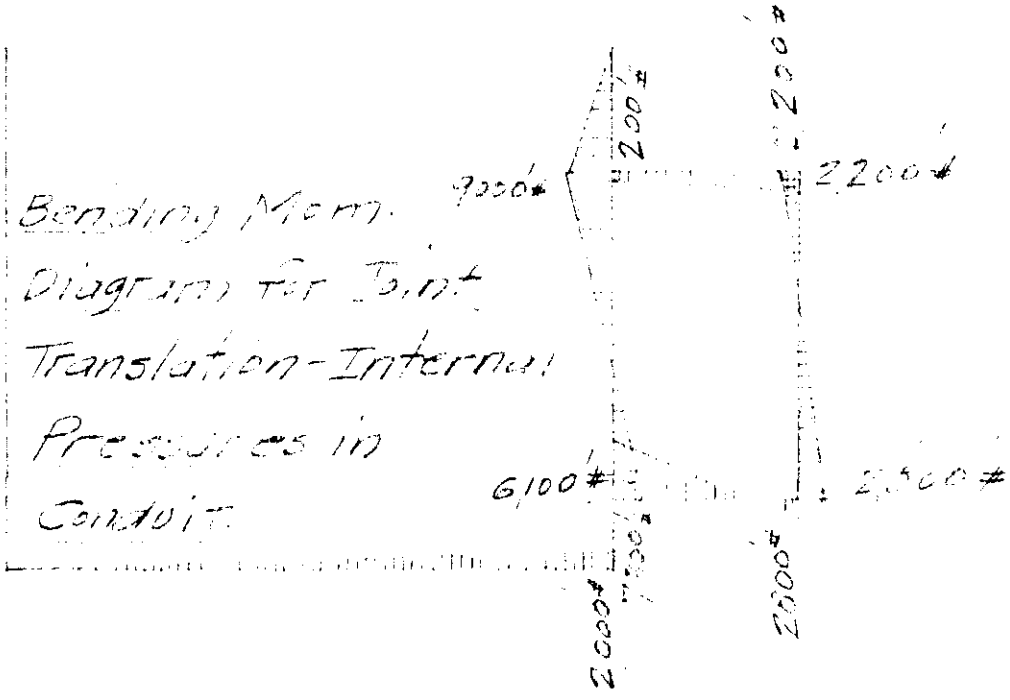
Subject Meadow Hill Pumping Station

Computation Transverse Section Thru Wet Pump Room

Computed by E. [illegible] Checked by ..... Date May 16, 194[illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet #4)



WAR DEPARTMENT

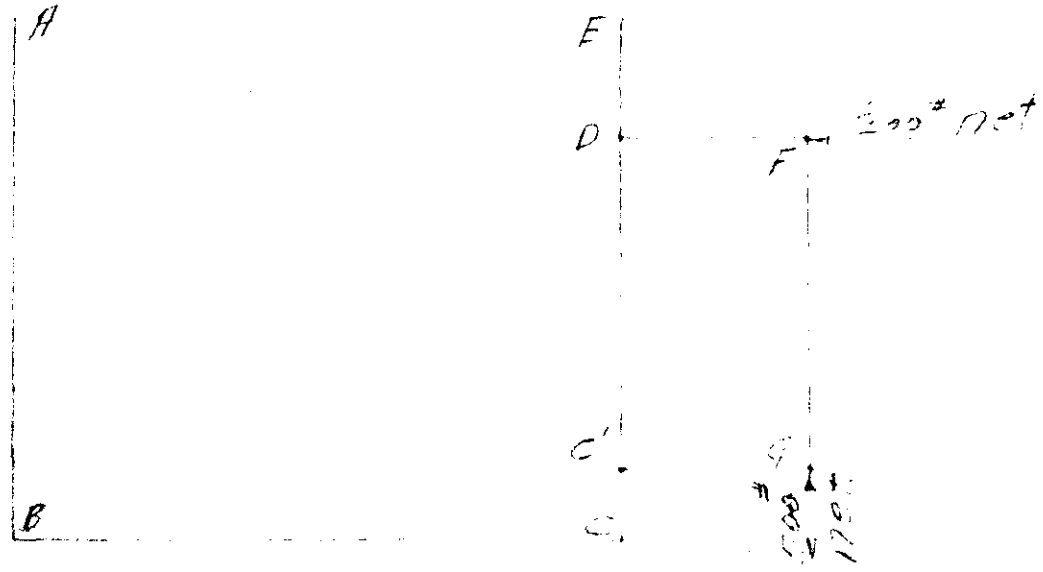
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Transverse Section Thru Wet Pump Room

Computed by E.M.V. **Checked by** W. [illegible] **Date** May 13, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10638



Assume that points E, D & C' remain fixed but that point D' is offset 0.01" relative to points E & C', then for member E-D mom. at "E" = mom. at "D"

$= K(1+C)\frac{d}{L} = \frac{1}{12}\left[4 \times 3{,}000{,}000 \times 230 (1+0.5) \frac{0.01}{60}\right] = 57{,}500'\#$

For mem D-C', mom. at D' = mom. at 'C'

$= \frac{1}{12}\left[4 \times 3{,}000{,}000 \times 84 \times 1.5 \times \frac{0.01}{165}\right] = 7{,}000'\#$

For vertical thrust of 300# member D-F takes 120# and member C'-G takes 300#.

For member F-G, mom. at F = mom. at "G"

$= \frac{1}{12}\left[4 \times 3{,}000{,}000 \times 30 \times 1.5 \times \frac{0.01}{165}\right] = 3{,}200'\#$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Transverse Section Thru Wet Pump Room

Computed by E.M.V. **Checked by** N.W.T. **Date** May 14, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3-10528

(Continued from sheet #44)

For member D-F assume that "D" & "F" remain fixed but that point "F" is offset 0.01" relative to point "D", then mom. at "D" = mom. at "F"

$= \frac{1}{12}\left[4 \times 3{,}000{,}000 \times 63 \times 1.5 \times \frac{0.01}{93}\right] = 10{,}200$ #.

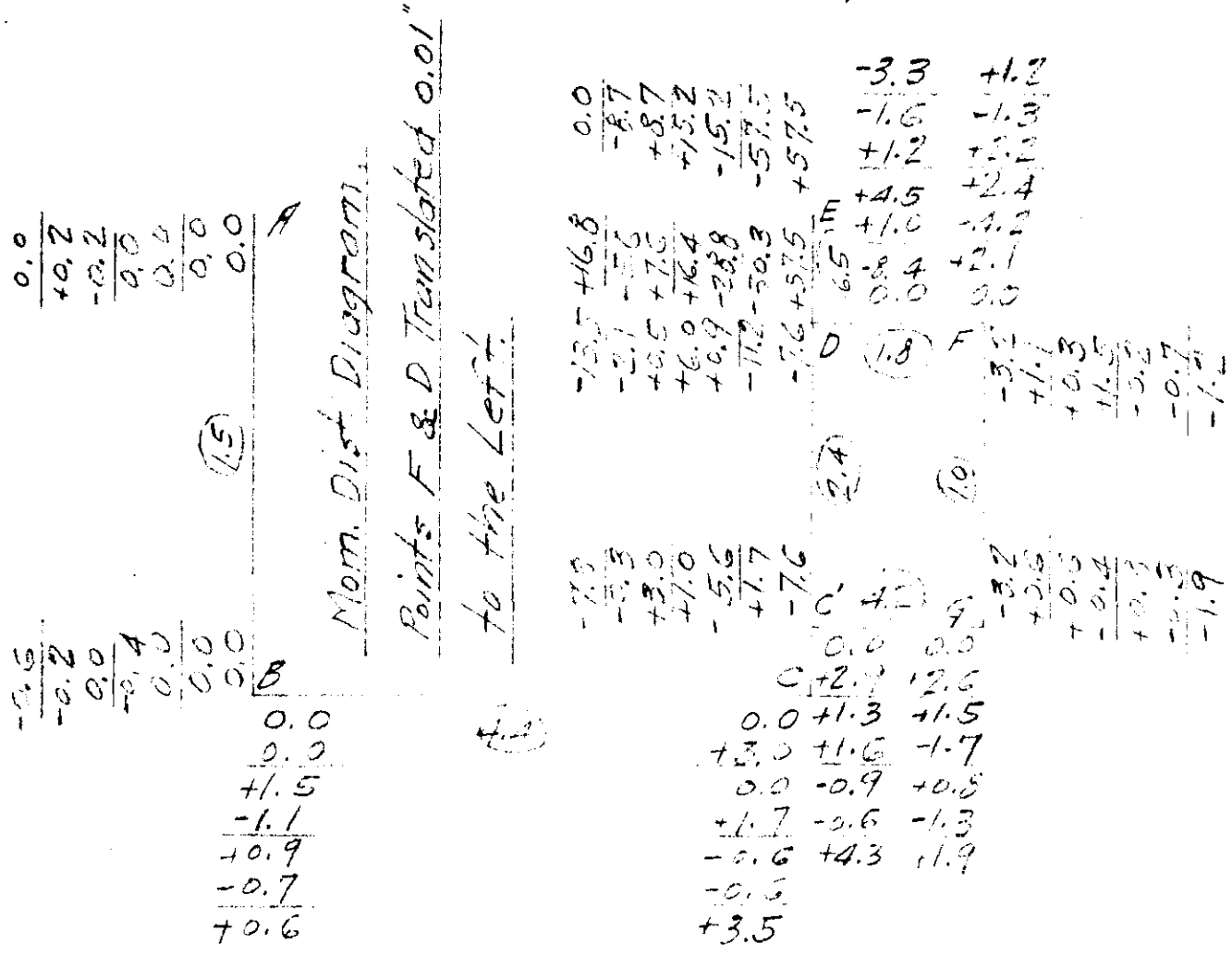
For member C'-G mom. at C' = mom. at G

$= \frac{1}{12}\left[4 \times 3{,}000{,}000 \times 149 \times 1.5 \times \frac{0.01}{93}\right] = 34{,}100$ #

Mom. Dist. Diagram.

Points F & D Translated 0.01"

to the Left.



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Transverse Section Thru Wet Pump Room.

Computed by [illegible] **Checked by** [illegible] **Date** May 14, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10938

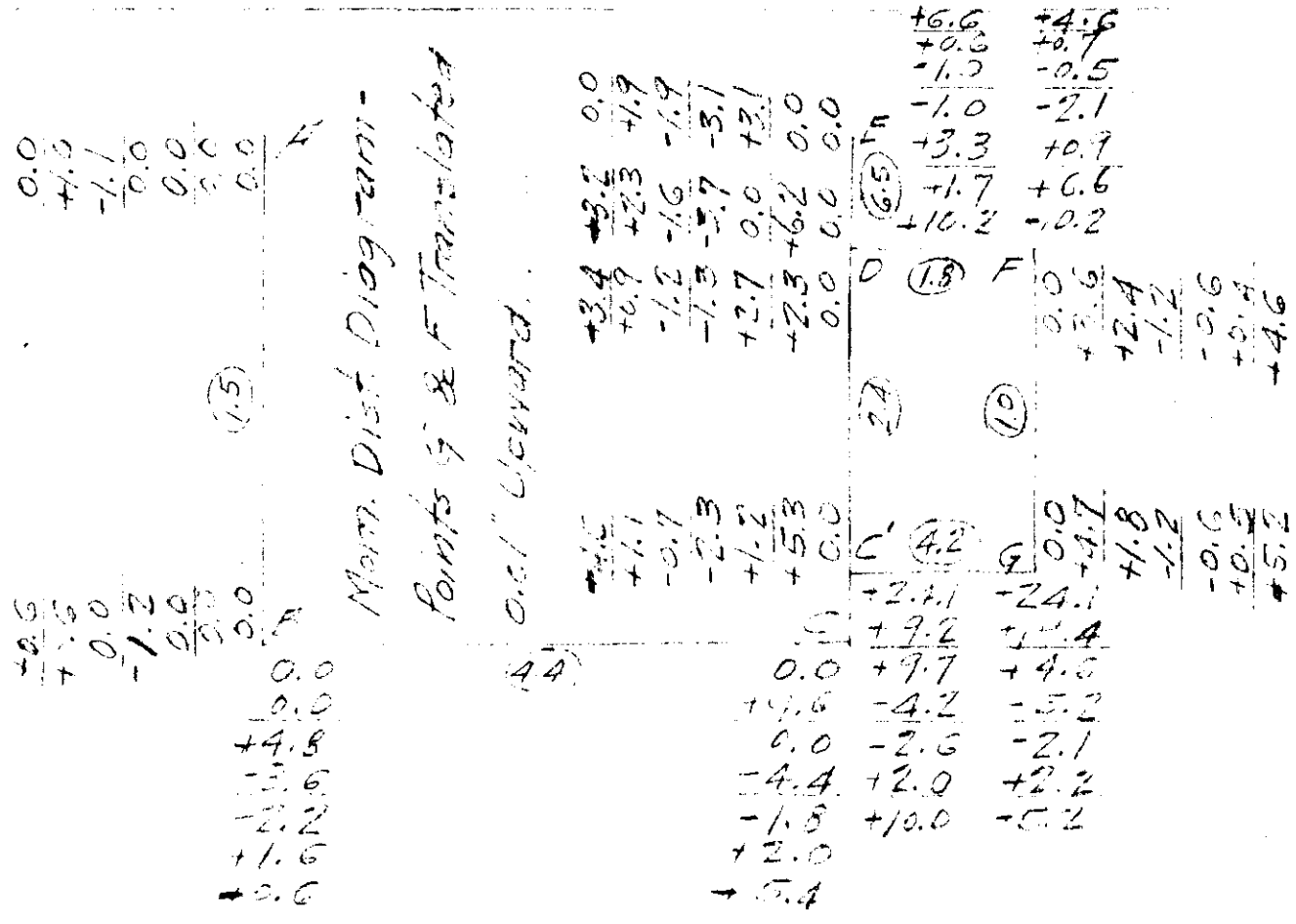
(Continued from sheet #45)

Member E-D. Shear at "D" = 3400#

" C-D. " "D" = 1500#

" G-F. " " "F" = 200#

Total = 5,100#



Member D-F. Shear at "F" = 1400#

" C'-G. " " "G" = 2000#

Total = 3,400#

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

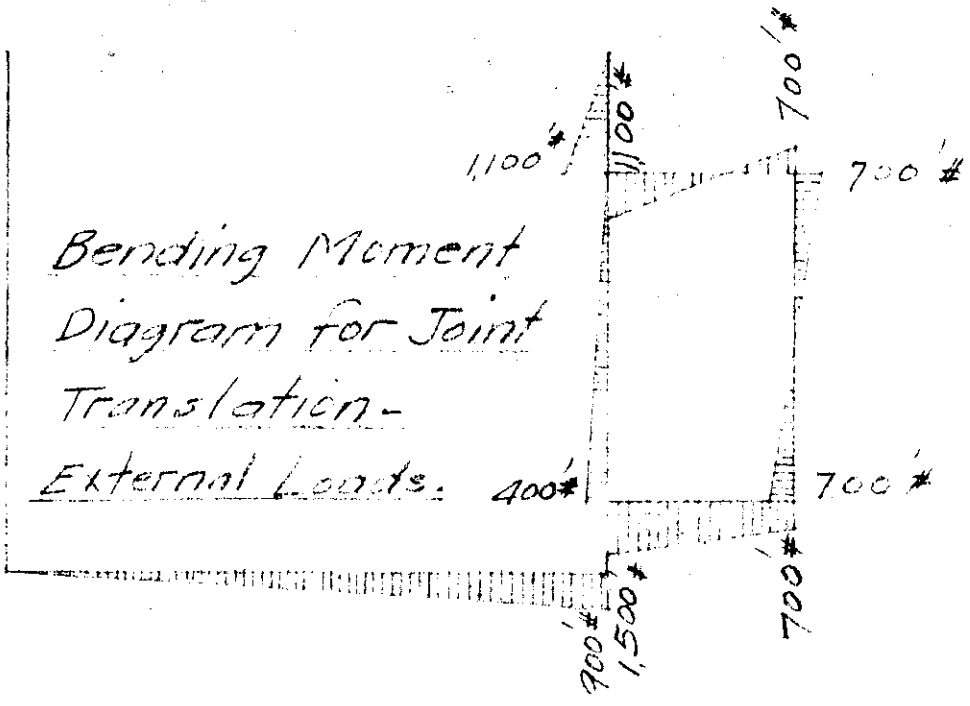
Subject Meadow Hill Pumping Station

Computation Transverse Section Thru Wet Pump Room

Computed by E. M. V. **Checked by** **Date** May 15, 1941

(Continued from sheet #4)

U. S. GOVERNMENT PRINTING OFFICE 3—10520



Design of base slab for pump room-

Max pos. mom. = 57,100#

" neg. " = 51,100# at point "B"

69,800# at " "C"

" shear = 17600#

Effective depth req'd = $\sqrt{\frac{57100}{123}}$ = 21.6"

Make slab 3½' thk. d = 31.5"

Unit shear = $\frac{17600}{12 \times \frac{7}{8} \times 31.5}$ = 53.#/□'

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Subject Meadow Hill Pumping Station
Computation Transverse Section Thru Wet Pump Room.
Computed by E.M.V. Checked by Date May 15, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet #47)

A_s for pos. mom. $= \dfrac{57{,}100 \times 12}{\frac{7}{8} \times 31.5 \times 18{,}000} = 1.38^{\square''} = 1\frac{1}{8}''^{\square}, 11''$ c.c.

A_s for neg. " $= \dfrac{51{,}100 \times 12}{\frac{7}{8} \times 31.5 \times 18{,}000} = 1.24^{\square''} = 1\frac{1}{8}''^{\square}, 12''$ c.c.

$\dfrac{69{,}800 \times 12}{\frac{7}{8} \times 31.5 \times 18{,}000} = 1.69^{\square''} = 1\frac{1}{4}''^{\square}, 11''$ c.c.

Unit bond $= \dfrac{17{,}600}{1.09 \times 5.0 \times \frac{7}{8} \times 31.5} = 117$ #/□" O.K.

Design of wall opposite conduit -

Max. pos. mom. = 6,500 #
" neg. " = 51,100 #
" shear = 10,800 #

Effective depth req'd $= \sqrt{\dfrac{51100}{147}} = 18.7$

Make wall 2'-0" thk. "d" = 20.5".

Unit shear $= \dfrac{10{,}800}{12 \times \frac{7}{8} \times 20.5} = 51$ #/□" O.K.

A_s for pos. mom. $= \dfrac{6500 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 0.24^{\square''} = \frac{5}{8}''^{\phi}, 12''$ c.c.

A_s for neg. " $= \dfrac{51{,}100 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 1.89^{\square''} = \begin{cases} 1\frac{1}{8}''^{\square}, 12'' \text{ c.c.} \\ \frac{7}{8}''^{\phi}, 12'' \text{ c.c.} \end{cases}$

Subject Meadow Hill Pumping Station
Computation Transverse Section Thru Wet Pump Room
Computed by E.M.V. Checked by ..... Date May 16, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Design of wall at conduit-

Max. pos. mom. = 27,300'#
" neg. " = 50,600# at bot.
12,400'# at top of cond.
" shear = 13,500#

Make wall 2'-0" thk, "d" = 20.5"

A_s for pos. mom. = $\frac{27,300 \times 12}{\frac{7}{8} \times 20.5 \times 18,000}$ = 1.02□" = 1"□, 12" c.c.

A_s for neg. mom. = $\frac{50600 \times 12}{\frac{7}{8} \times 20.5 \times 18,000}$ = 1.89□" = 1 1/8"□, 12" c.c. ; 7/8"φ, 12" c.c.

A_s for neg. mom. at top of cond. = $\frac{12,400 \times 12}{\frac{7}{8} \times 20.5 \times 18,000}$ = 0.46□" = 3/4"φ, 12" c.c.

Design of conduit wall-

Max. mom. at bot. = 17,200#
" " at center = 21,600#
" shear = 9,700#

Effective depth req'd = $\sqrt{\frac{21600}{123}}$ = 13.3"
Make wall 1'-6" thk, "d" = 14.5"
Unit shear = $\frac{9700}{12 \times \frac{7}{8} \times 14.5}$ = 64#/□" O.K. with special anch.

Subject: Meadow Hill Pumping Station
Computation: Transverse Section Thru Wet Pump Room
Computed by: E.M.V. Checked by: Date: May 17, 1941

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(Continued from sheet #49)

A_s at bot. of wall $= \frac{17200 \times 12}{\frac{7}{8} \times 14.5 \times 18000} = 0.90\square'' = \frac{3}{4}''\phi$, 6" c.c.

A_s at center of wall $= \frac{21600 \times 12}{\frac{7}{8} \times 14.5 \times 18000} = 1.13\square'' = \frac{7}{8}''\phi$, 6" c.c.

Design of conduit base –

Max. mom. = 35,500 + 1,500 = 37,000'#

" shear = 9,500#

Effective depth reqd $= \sqrt{\frac{37000}{147}} = 15.9''$

Make base slab 2'-0" thk. d = 20.5"

Unit shear $= \frac{9500}{12 \times \frac{7}{8} \times 20.5} = 44$ #/□" O.K.

$A_s = \frac{37000 \times 12}{\frac{7}{8} \times 20.5 \times 18000} = 1.37\square'' = 1''\phi$, 6" c.c.

Design of conduit top slab –

Max. mom. tension at bot. = 15,200'#

" " " " top = 8,600'#

" shear = 3,500#

Effective depth reqd $= \sqrt{\frac{15200}{123}} = 11.1''$

Make slab 1'-5" thk. d = 14.5"

A_s for bot. steel $= \frac{15200 \times 12}{\frac{7}{8} \times 14.5 \times 18000} = 0.80\square'' = \frac{3}{4}''\phi$, 6" c.c.

WAR DEPARTMENT

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Subject: Meadow Hill Pumping Station

Computation: Transverse Section Thru Wet Pump Room

Computed by: E.M.V. Checked by: ..... Date: May 17, 1941

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(Continued from sheet #50)

As for top steel = $\frac{8600 \times 12}{\frac{7}{8} \times 14.5 \times 18{,}000} = 0.45\square'' = \frac{3}{4}''\phi$, 12" c.c.

Max. direct tension on conduit wall = 4200#

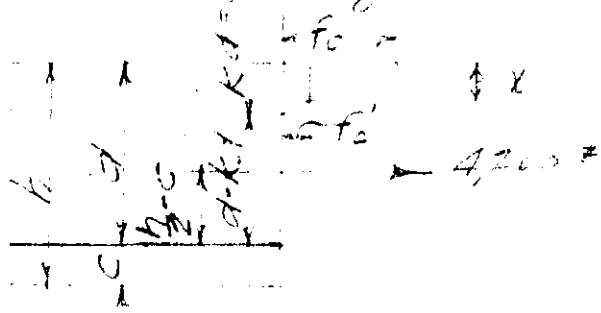
$$p = \frac{2.0 \times 0.44}{12 \times 14.5} = 0.00473$$

$$k = -12 \times 0.00473 + \sqrt{2 \times 12 \times 0.00473 + (12 \times 0.00473)^2}$$

$$= -0.05676 + 0.3416 = 0.28$$

$$f_c = \frac{2 \times 17{,}200}{0.28 \times \frac{7}{8}(14.5)^2} = 667\ \#/\square''$$

$$f_s = \frac{17200 \times 12}{\frac{7}{8} \times 14.5 \times 0.88} = 18{,}500\ \#/\square''$$



Assume $f_c' = 100\ \#/\square''$; then $x'' = 3.4''$

$$100 \times 12 \times 3.4 \times 12.80 + \tfrac{1}{2} \times 100 \times 12 \times 0.60 \times 10.9 > 4200 \times 5.5$$

Assume $f_c' = 50\ \#/\square''$; then $x = 3.7''$

$$50 \times 12 \times 3.7 \times 12.65 + \tfrac{1}{2} \times 50 \times 12 \times 10.6 > 4200 \times 5.5$$

Subject: Meadow Hill Pumping Station
Computation: Transverse Section Thru Wet Pump Room.
Computed by: E.M.V. Checked by: ..... Date: May 19, 1941

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(Continued from sheet #51)

Assume $f'_c = 35$ #/□"; then $x = 3.7$"

$$3.5 \times 12 \times 3.7 \times 12.65 + \tfrac{1}{2} \times 3.5 \times 12 \times 10.6 < 4200 \times 5.5$$

$f'_c = 38$ #/□"

Reduction in conc. stress $= 38\left(\frac{4.0+3.7}{2}\right) \times 12 = 1750$ #

Increase in steel stress $= \frac{4200 - 1750}{0.88} = 2800$ #/□"

Total steel stress $= 18500 + 2800$

$= 21300$ #/□" O.K.

Max. direct tension on top slab $= 9700$ #

$k = 0.28$

$kd = 4.0$"

$f_c = \dfrac{2 \times 15200}{0.28 \times \frac{7}{8}(14.5)^2} = 570$ #/□"

$f'_c = 100$ #/□"

Reduction in conc. stress $= 100\left(\frac{4.0+3.4}{2}\right) \times 12 = 2200$ #

Increase in steel stress $= \frac{9700 - 2200}{0.88} = 8500$ #/□"

$T_s = \dfrac{15200 \times 12}{\frac{7}{8} \times 14.5 \times 0.88}$

Total $= 16300$ / 24600 #/□" OK

WAR DEPARTMENT

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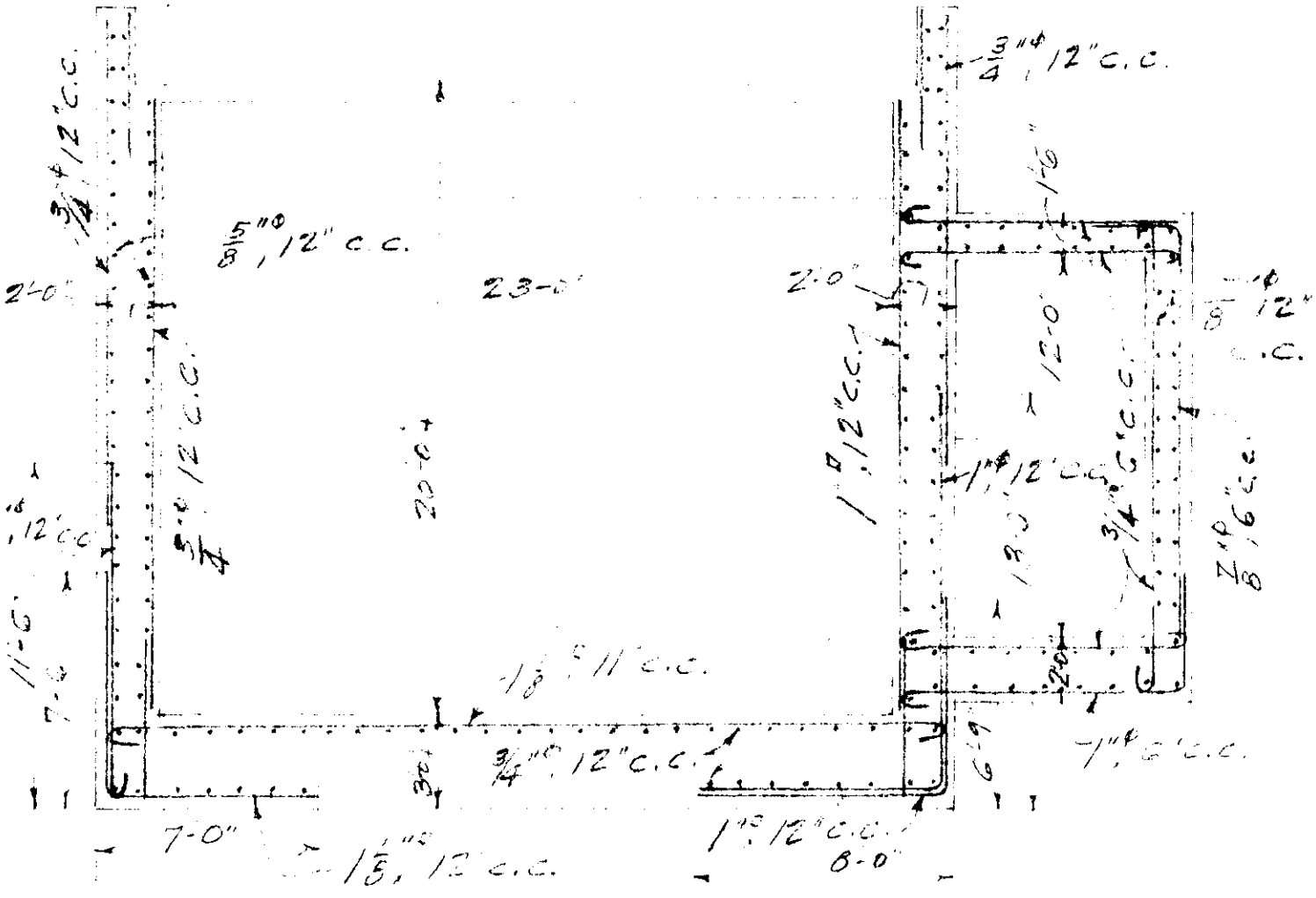
Subject Meadow Hill Pumping Station

Computation Transverse Section Thru Wet Pump Room

Computed by E. M. V. Checked by ..... Date May 7, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10028



Transverse Section Thru Wet Pump Room

WAR DEPARTMENT

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Subject: Meadow Hill Pumping Station

Computation: Dry Pump Room

Computed by: E. M. [illegible] Checked by: W. W. Z. Date: May 20, [illegible]

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It is assumed that the end wall and base slab act as a continuous frame, with the end wall assumed simply supported at the operating floor and at the boiler room floor. It is further assumed that the base slab is [illegible] supported under the division wall between the dry and wet pump rooms.

Assumed end wall [illegible] thk

" base 3'-0" thk.

Loading Diagram

Member	Length	Thickness	I	$\bar{l}$	K
A-B	105"	21"	9,261"⁴	[illegible]	1.2
B-C	129"	21"	9,261"⁴	[illegible]	1.0
C-D	213"	36"	46,656	[illegible]	3.0

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

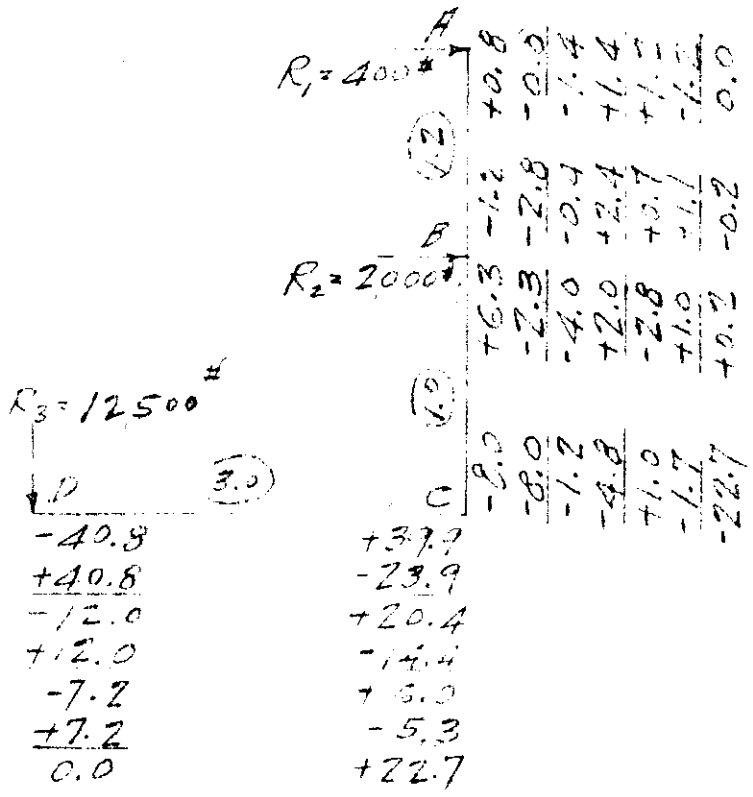
Subject: Meadow Hill Pumping Station

Computation: Dry Pump Room

Computed by: E.M.V. Checked by: W.W.Z. Date: May 21, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10628

(Continued from sheet #54)



A	+0.8	-0.0	-1.4	+1.4	+1.2	-1.2	0.0		
	-1.2	-2.8	-0.4	+2.4	+0.7	+1.1	-0.2		
B	+6.3	-2.3	-4.0	+2.0	-2.8	+1.0	+0.2		
	-8.0	-8.0	-1.2	-4.8	+1.0	-1.7	-22.7		

Member A-B. Shear at "A" = 400#

" " "B" = 900

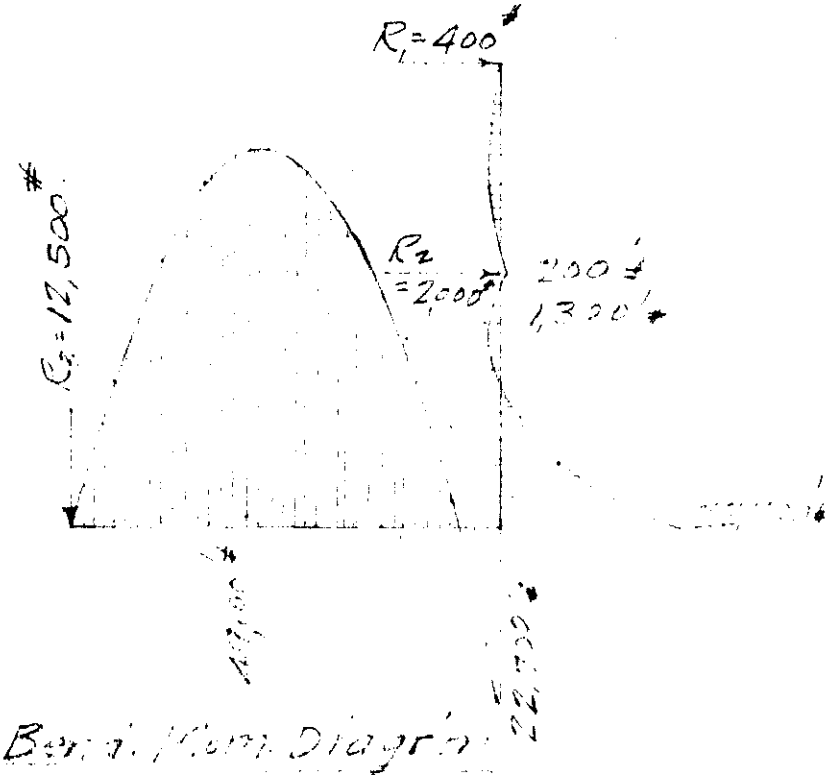
" " "B" = 1,100

" B-C " " "C" = 6,800

" " "C" = 14,000

" C-D " " "D" = 12,500

Mom. Dist. Diagram.

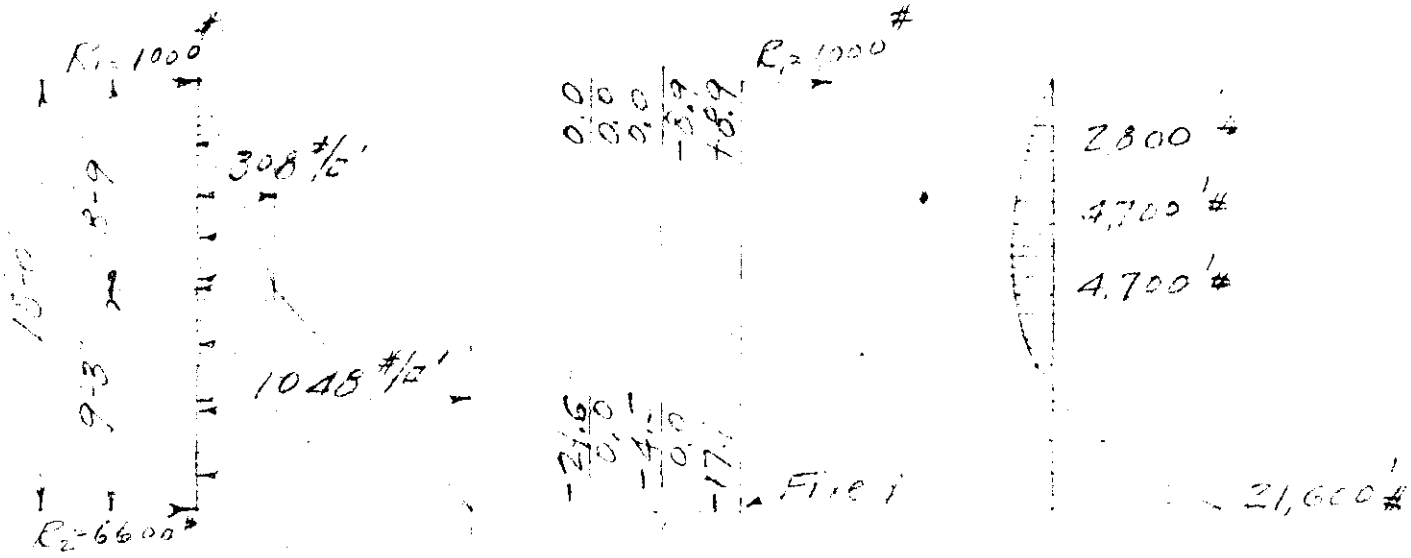


Bend. Mom. Diagr'n

Subject: Meadow Hill Pumping Station
Computation: Dry Pump Room
Computed by: E.M.T. Checked by: ..... Date: May 21, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Wall opposite conduit -
Assume wall simply supported at the top.
Assume wall fixed at the base for neg. mom.
and 75% fixed for pos. mom.



For max. pos. mom. bot. of wall is assumed 75% fixed. Pos. mom. = 7400 #.

WAR DEPARTMENT

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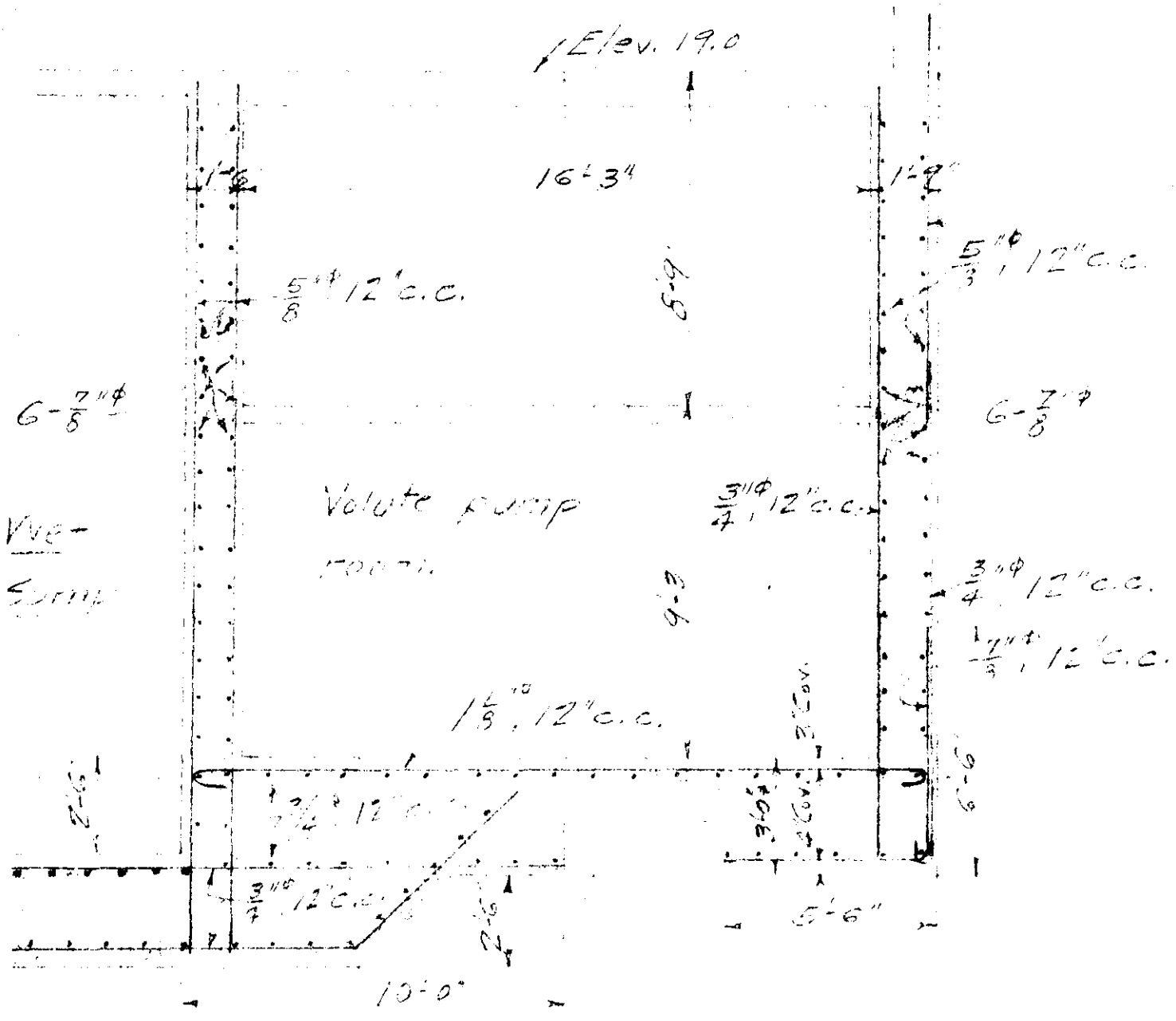
Subject Meadow Hill Pumping Station

Computation Dry Pump Room

Computed by E.M.V. Checked by ..... Date May 23, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3--10538



Section Thru Dry Pump Room

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

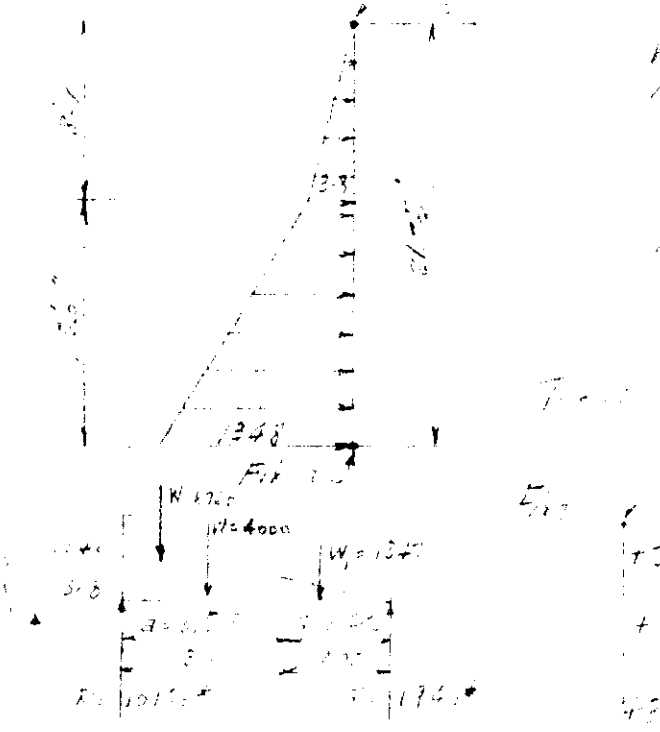
Page

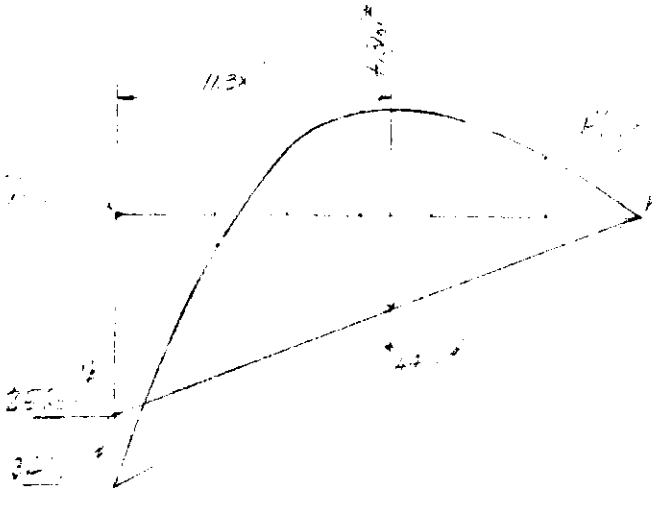
Subject

Computation

Computed by Checked by Date

U. S. GOVERNMENT PRINTING OFFICE 3-10028



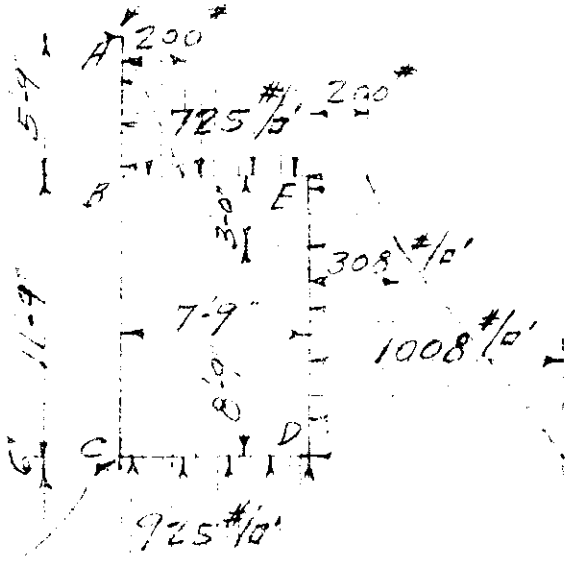


Subject Meadow Hill Pumping Station
Computation Dry Pump Room
Computed by E.M.V. Checked by ..... Date May 21, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10624

Conduit and pump room wall -

Assumed hinged



Assumed fixed

Loading Diagram
External Loading

Member	Length	Thickness	I	$\frac{I}{l}$	K.
A-B	69"	24"	13,824	202	4.9
B-C	141"	24"	13,824	98	2.4
C-D	93"	24"	13,824	147	3.6
D-E	141"	18"	5,832	41	1.0
E-B	93"	18"	5,832	63	1.5

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Dry Pump Room

Computed by E.M.V. **Checked by** **Date** May 21, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet #57)

Member A-B. Shear at A = 100#

" " B = 700

" B-E. " " B = 100

" " C = 100

" C-D. " " C = 3,100

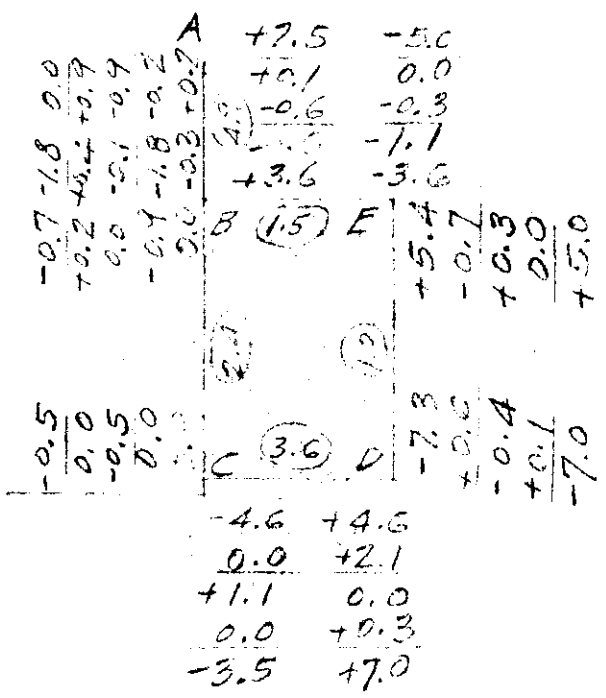
" " D = 4,100

" D-E. " " D = 4,300

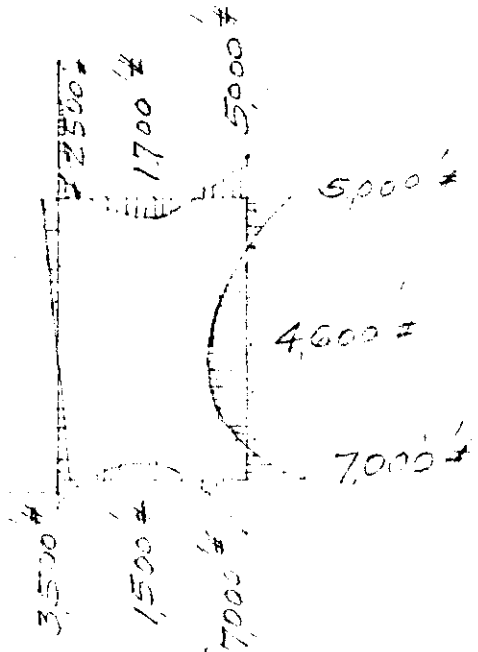
" " E = 2,600

" E-B. " " E = 3,100

" " B = 2,500



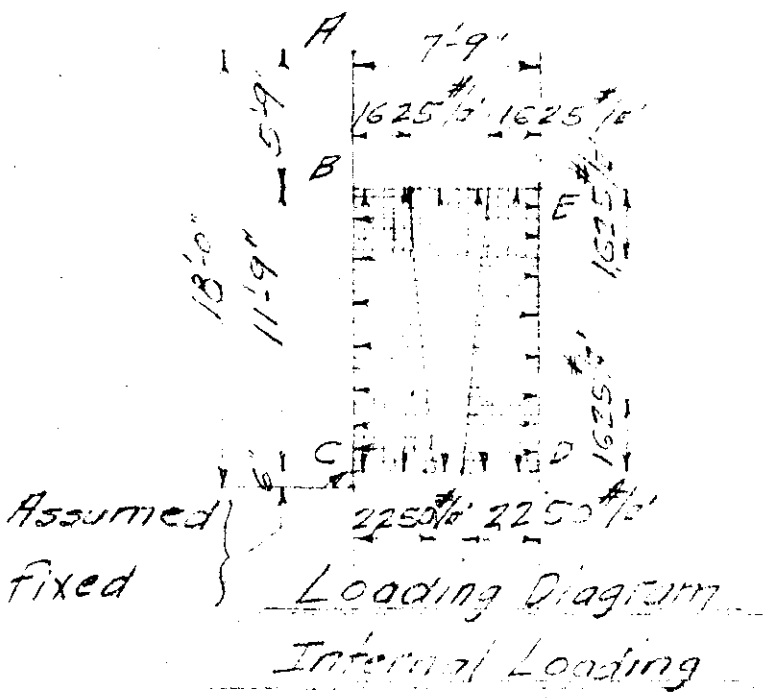
Mom. Dist. Diagram

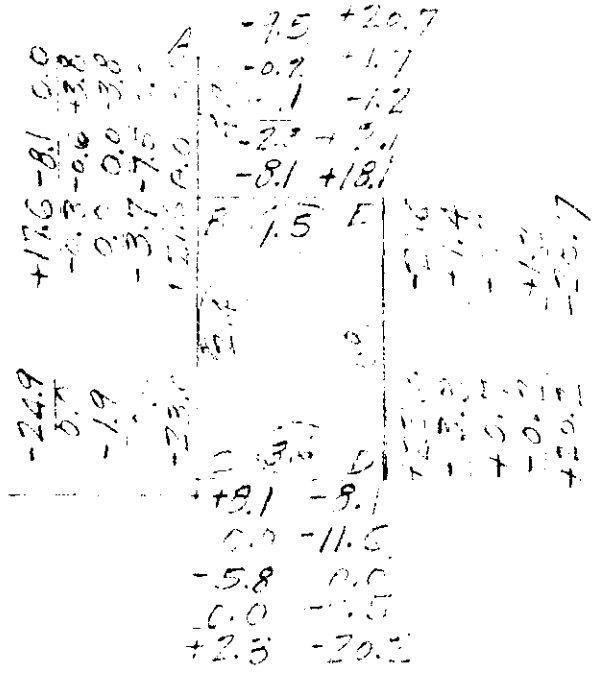


Bending Mom. Diagram.
External Loads.

Subject Meadow Hill Pumping Station
Computation Dry Pump Room
Computed by E.M.V. **Checked by** ..... **Date** May [illegible] 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10625





Member	Length	Thickness	I	$\frac{I}{L}$	K
A-B	69"	24"	13,824 $''^4$	200	4.9
B-C	141	24"	13,824 $''^4$	98	2.4
C-D	93	24"	13,824 $''^4$	149	3.6
D-E	141	18"	5,832 $''^4$	41	1.0
E-B	93	18"	5,832 $''^4$	63	1.5

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Dry Pump Room

Computed by E.M.V. **Checked by** **Date** May 22, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet #59)

Member A-B. Shear at A = 1,400#

" " " B = 1,400

" B-C. " " "B" = 10,100

" " "C" = 12,700

" C-D. " " "C" = 4,700

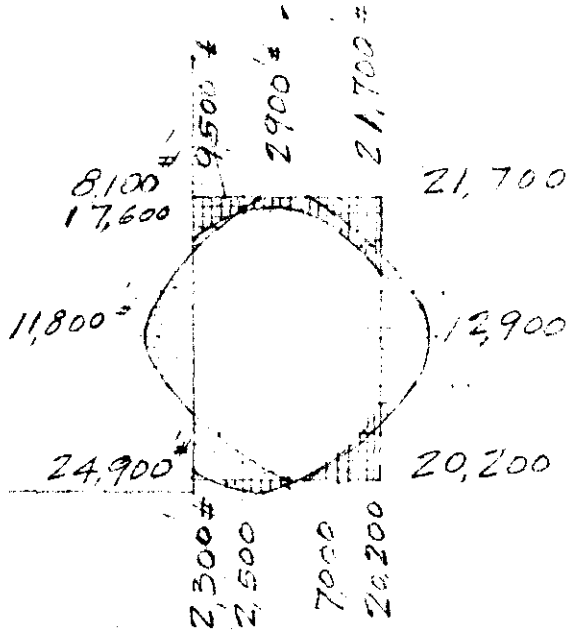
" " D = 8,600

" D-E. " " "D" = 12,000

" " "E" = 10,800

" E-B. " " E = 7,700

" " "B" = 4,900



Bending Mom. Diagram

No Joint Translation

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Dry Pump Room

Computed by E.M.V. **Checked by** ..... **Date** May 22 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet # 60)

Design of base slab -

Max. pos. mom. = 49,100 #

" neg. " = 22,700 #

" shear = 14,600 #

Effective depth = $\sqrt{\frac{49100}{123}}$ = 20."

Make base 3'-6" thk. d" = 31.5"

Unit shear = $\frac{14600}{12 \times \frac{7}{8} \times 31.5}$ = 44 #/□' O.K.

A_s for pos. mom. = $\frac{49100 \times 12}{\frac{7}{8} \times 31.5 \times 18000}$ = 1.19□" = 1 1/8□", 12" c.c.

A_s for neg. mom. = $\frac{22700 \times 12}{\frac{7}{8} \times 31.5 \times 18000}$ = 0.55□" = 7/8□", 12" c.c.

Design of end wall -

Max. pos. mom. nominal

" neg. " = 22,700 #

" shear = 6,800 #

Make wall 1'-9" thk. d" = 17.5"

A_s = $\frac{22700 \times 12}{\frac{7}{8} \times 17.5 \times 18000}$ = 0.99□" = 1□" bars, 12" c.c.

Unit shear = $\frac{6800}{12 \times \frac{7}{8} \times 17.5}$ = 37 #/□' O.K.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

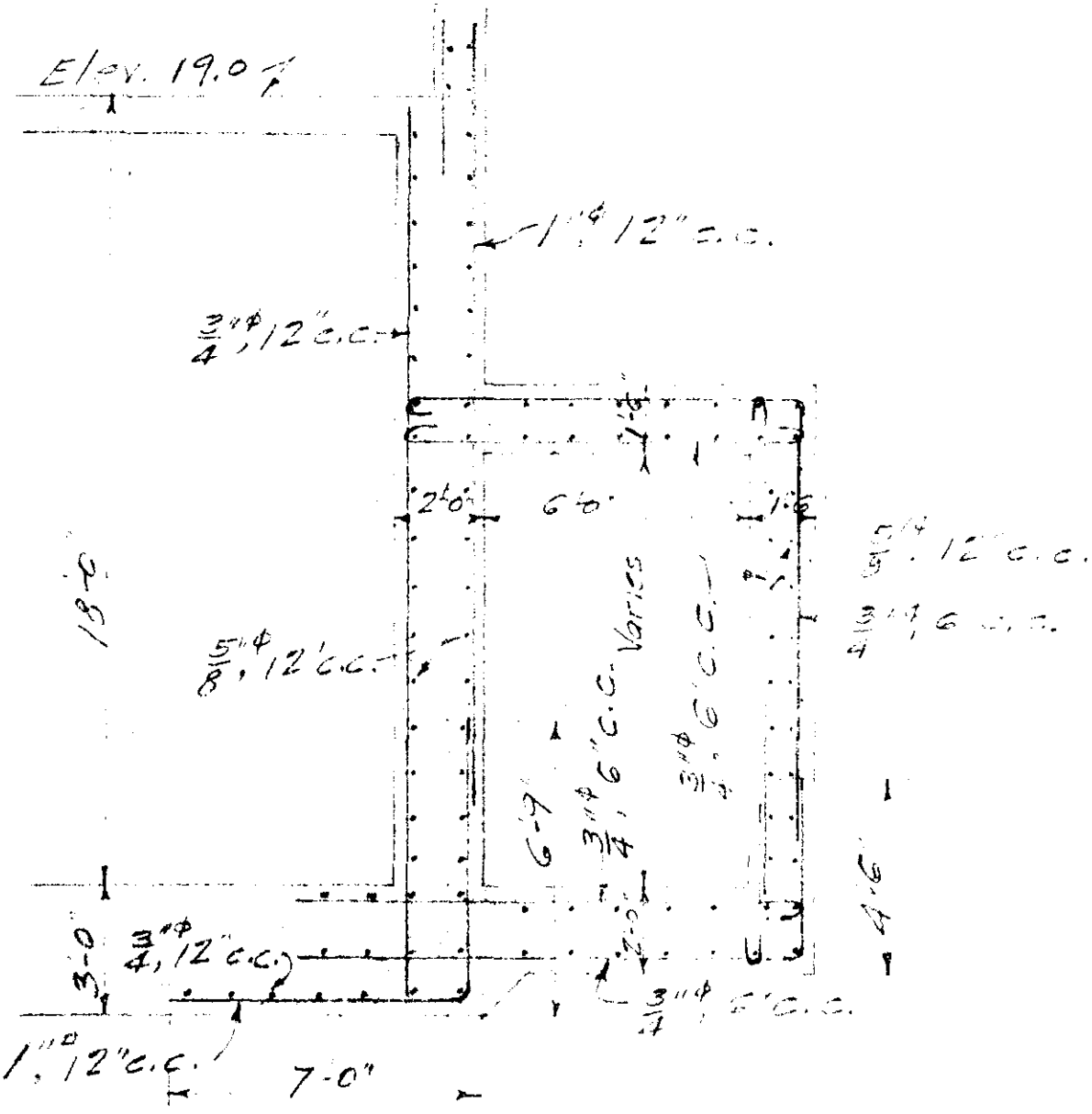
Page 5.

Subject Meadow Hill Pumping Station

Computation Dry Pump Room

Computed by E. M. V. **Checked by** **Date** May 26, 19

U. S. GOVERNMENT PRINTING OFFICE 3—10028



Transverse Section Thru Conduit and Dry Pump Room.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 66.

Subject: Meadow Hill Pumping Station

Computation: Dry Pump Room

Computed by: E.M.V. Checked by: Date: May 24, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10486

Design of wall opposite conduit -

Max. pos. mom. = 7400 #

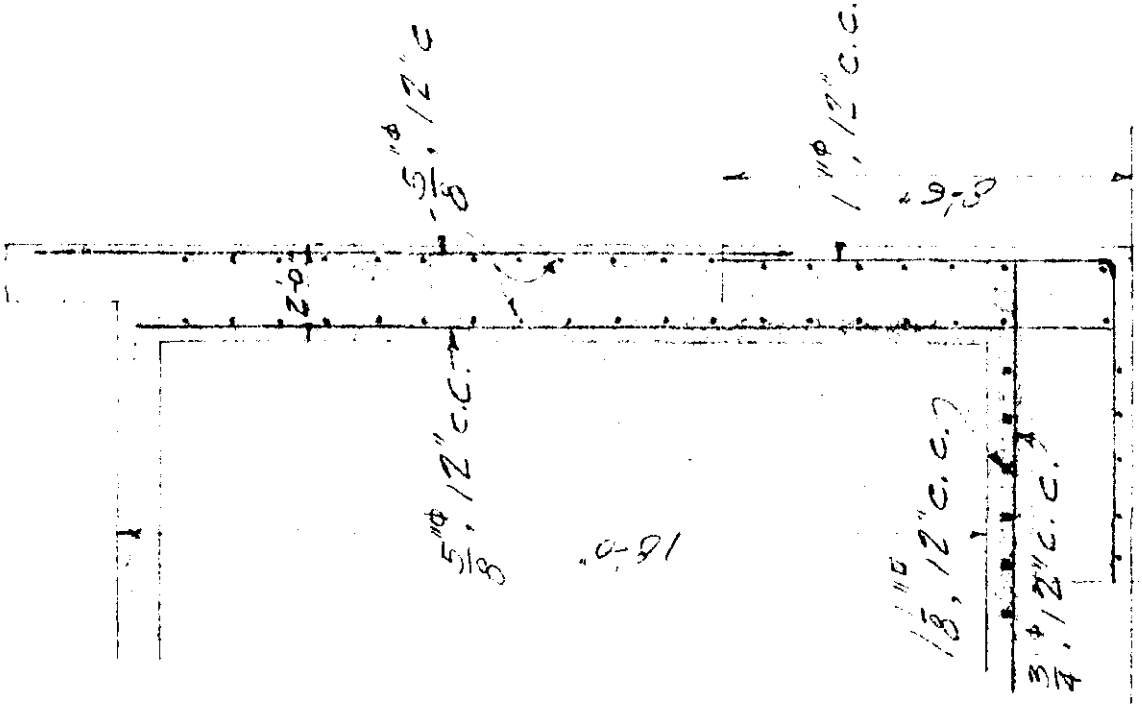
" neg. = 21,600 #

" shear = 6,600 #

Make wall 2'-0" thk; d = 20.5"

A_s for pos. mom. = $\frac{7400 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000}$ = 0.28□" Use $\frac{5}{8}$"φ, 12" c.c.

A_s for neg. mom. = $\frac{21600 \times 12}{\frac{7}{8} \times 20.5 \times 18000}$ = 0.80□" = 1"φ, 12" c.c.



Section Thru Wall Opp. Conduit in Dry Pump Room.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Meadow Hill Pumping Station

Computation: Dry Pump Room

Computed by: E. M. V. Checked by: Date: May 24 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10523

Design of conduit and adjoining pump room wall –

Pump room wall max pos. mom. = 11800 #.

" neg. " = 24,900 #

" shear = 12,700 #.

Make wall 2'-0" thk, "d" = 20.5"

Unit shear = $\frac{12700}{12 \times \frac{7}{8} \times 20.5}$ = 59 #/□" O.K.

A_s for pos. mom. = $\frac{11800 \times 12}{\frac{7}{8} \times 20.5 \times 18000}$ = 0.44 □" = 3/4", 12" c.c.

A_s for neg. mom. at bot. of conduit = $\frac{24900 \times 12}{\frac{7}{8} \times 20.5 \times 18}$

= 0.93 □" = 1", 12" c.c.

A_s for neg. mom. at top of conduit = $\frac{17600 \times 12}{\frac{7}{8} \times 20.5 \times 18}$

= 1.65 □" = 1", 12" c.c.

Conduit base –

Max. pos. mom. = [illegible] #

" neg. = [illegible] #.

" shear = 8,600 #

A_s for neg. mom. = $\frac{20,200 \times 12}{\frac{7}{8} \times 19.5 \times 18000}$ = 0.77 □" = 3/4", [illegible] c.c.

Make base slab 2'-0" thk.

Subject: Meadow Hill Pumping Station
Computation: Dry Pump Room
Computed by: E. M. V. Checked by: Date: May 26, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10629

(Continued from sheet #64)

Conduit wall-

Max. pos. mom. = 12,900 - 4,600 = 8300 #.

" neg. " = 21,700 - 5,000 = 16,700 #.

" shear = 12,000 - 4300 = 7,700 #.

Effective depth = $\sqrt{\frac{16,700}{147}}$ = 10.7"

Make wall 1'-6" thk. d = 14.5"

A_s for pos. mom. = $\frac{8300 \times 12}{\frac{7}{8} \times 14.5 \times 18000}$ = 0.44 □" = $\frac{3}{4}$"ϕ 6" c.c.

A_s for neg. " = $\frac{16,700}{8300} \times 0.44$ = 0.89 □" = $\frac{3}{4}$"ϕ 6" c.c.

Conduit roof slab-

Max. neg. mom. = 21,700 - 5000 = 16,700 #.

Make slab 1'-6" thk.

Use $\frac{3}{4}$"ϕ bars 6" c.c.

WAR DEPARTMENT

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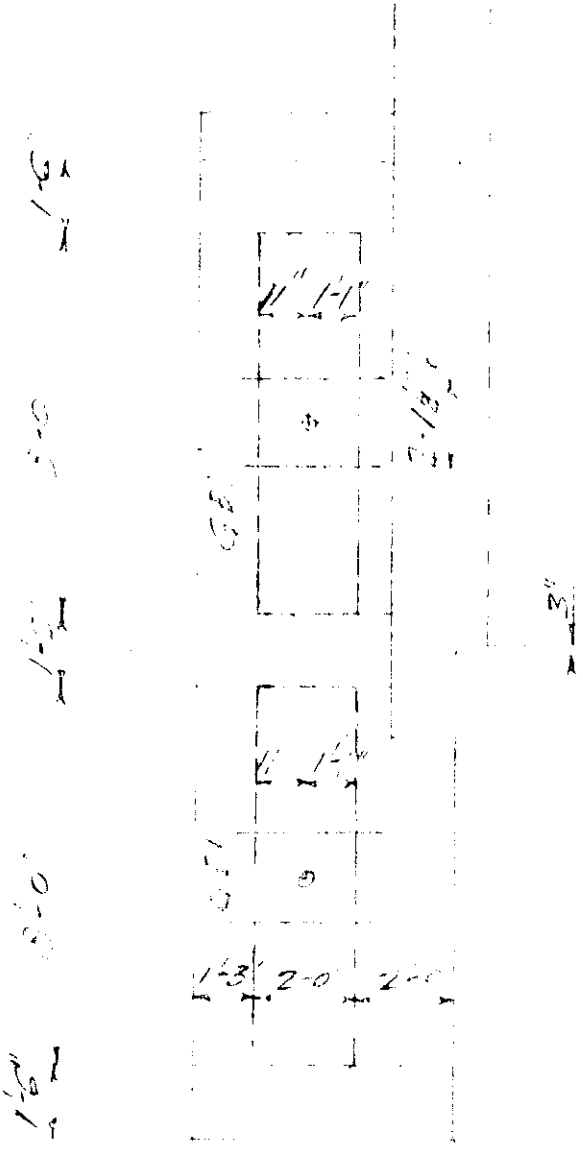
Page 69

Subject: Meadow Hill Pumping Station

Computation: Gate Chamber at Intake

Computed by: E.M.V. Checked by: Date: May 27, 1941

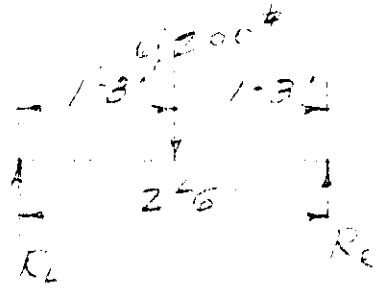
U. S. GOVERNMENT PRINTING OFFICE 3—10828



Plan of Roof Slab over Gate Chamber

℄ Intake structure

Load from gate 13,300#



$R_L = R_R = 3100^{\#}$

$M = 3100 \times 1.25 = 3900'^{\#}$

Sect. mod. reqd. $= \frac{3900 \times 12}{18000} = 2.6^{\text{in}^3}$

Use 1-4" [7¼#

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page [illegible]

Subject [illegible]

Computation [illegible]

Computed by [illegible] Checked by [illegible] Date [illegible]

U. S. GOVERNMENT PRINTING OFFICE 3-10528

[illegible]

WAR DEPARTMENT

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Page 71

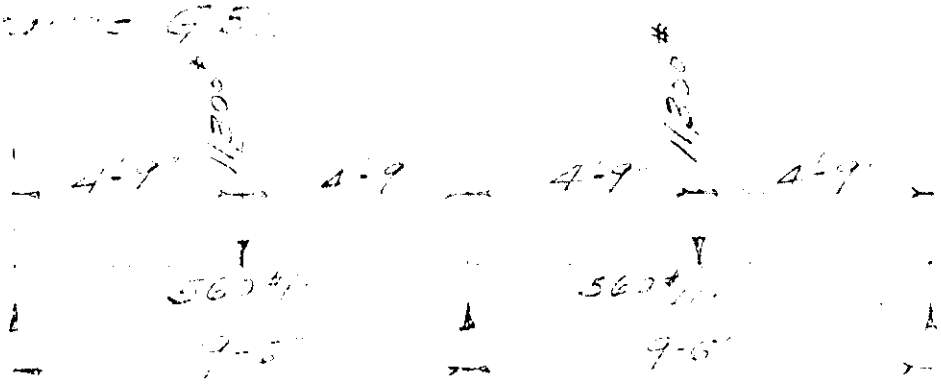
Subject: Meadow Hill Pumping Station

Computation: Gate Chamber of Intake

Computed by: E. M. [illegible] Checked by: Date: May 29, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Beam = 6.5"



$R_1 = 5,500^{\#}$ $R_2 = 22,200^{\#}$ $R_3 = 5500^{\#}$

Max. pos. moment $= \frac{13}{24} \times 11300 \times 9.5 = 21,800$

$\frac{9}{128} \times 560 \times (9.5)^2 = 3,600$

Total = 25,400 #.

Max. neg. moment $= \frac{3}{8} \times 11,300 \times 9.5 = 20,100$

$\frac{16}{128} \times 560 \times 9.5^2 = 6,100$

Total = 26,200 #.

Effective depth reqd $= \sqrt{\frac{25,400 \times 12}{123 \times 15}} = 12.7"$

Total depth of beam 3'-0", effective depth = 26.5"

A_s for pos. [illegible] $= \frac{25,400 \times 12}{\frac{7}{8} \times 26.5 \times 18,000} = 0.73^{\square"}$

A_s for neg. [illegible] $= \frac{26,200 \times 12}{\frac{7}{8} \times 26.5 \times 18,000} = 0.75^{\square"}$

Use $2\text{-}\frac{3}{4}$" = 0.44□" = 0.58□" for both pos. and neg. mom.

Unit shear $= \frac{11100}{15 \times \frac{7}{8} \times 26.5} = 32$ #/□" No stirrups reqd.

WAR DEPARTMENT

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Page 72

Subject Meadow Hill Pumping Station

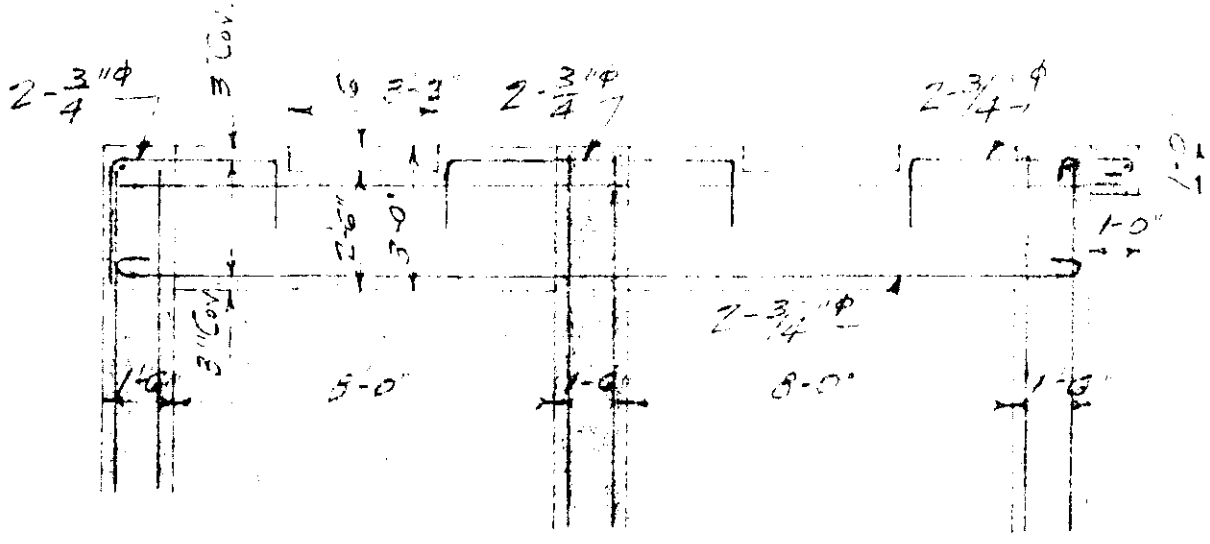
Computation Gate Chamber at Intake

Computed by E.M.V. Checked by Date Mar. 29 '44

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet # 69)

Unit bond stress = $\frac{11100}{2 \times 2.36 \times \frac{7}{8} \times 26.5}$ = 101 #/□" O.K.



Beams "B G 1." Stem 1'-3" wide

WAR DEPARTMENT

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Page 73

Subject: Meadow Hill Pumping Station

Computation: Gate Chamber at Intake

Computed by: E.M.V. Checked by: Date: May 29, 1941

U.S. GOVERNMENT PRINTING OFFICE 3—10528

Header beam at inlet end of conduit

Assume that entire thrust against the gate will be taken at its upper and lower edges.

Average head of water against gate = 31.5 ft.

Pressure against gate = 52.5 × 31.5 × 8.5 × 6.0

= 94,500#

Pressure against header bm. from gate = 47,300#

" " " " above gate = 10,600

Total = 57,900#

$M = \frac{1}{8} \times 57900 \times 3.75 = 56,000$ #.

$d = \sqrt{\frac{56000 \times 12}{123 \times 18}} = 17.4''$

Make header 20" thk; d = 20.5"

Unit shear = $\frac{57900}{2 \times 18 \times \frac{7}{8} \times 20.5} = 89$ #/□" O.K.

$A_s = \frac{56,000 \times 12}{\frac{7}{8} \times 20.5 \times 18,000} = 2.08$ □" Use 4-$\frac{7}{8}$"φ @ 0.60□" = 2.40□"

Unit bond = $\frac{57900}{2 \times 4 \times 2.75 \times \frac{7}{8} \times 20.5} = 147$ #/□" O.K.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 74

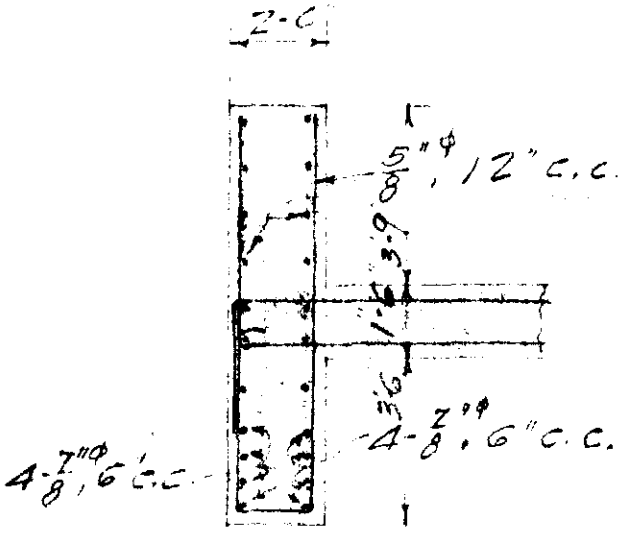
Subject: Meadow Hill Pumping Station

Computation: Gate Chamber at Intake

Computed by: E.M.V. Checked by: Date: May 29, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet # 71)



Section at Inlet End of Conduit

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Gate Chamber at Intake

Computed by E.M.V. **Checked by** **Date** May 29, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Conduit base slab extension -

Gross soil reaction = 2600 #/□'

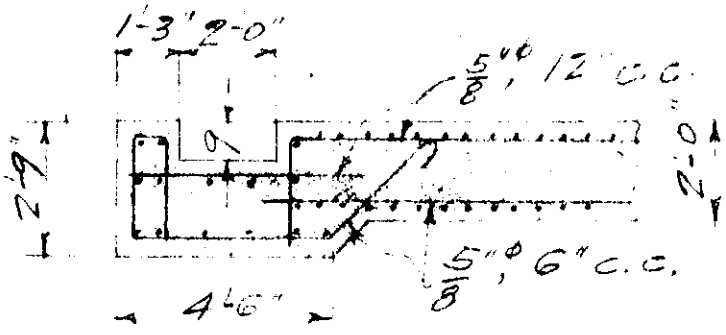
Deduct 2×1.50×8.5×62.5 = 830

Net = 1,770 #/□'

Cantilever mom. = 1,770 × 4.25 × 2.13 = 16000 '#

$d' = \sqrt{\frac{16,000}{123}} = 11.4''$ Actual d = 19.5"

$A_s = \frac{16000 \times 12}{\frac{7}{8} \times 19.5 \times 18000} = 0.63 \square'' = \frac{5}{8}''\phi$ bars 6" c.c.



Section Thru Conduit Base at Intake.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

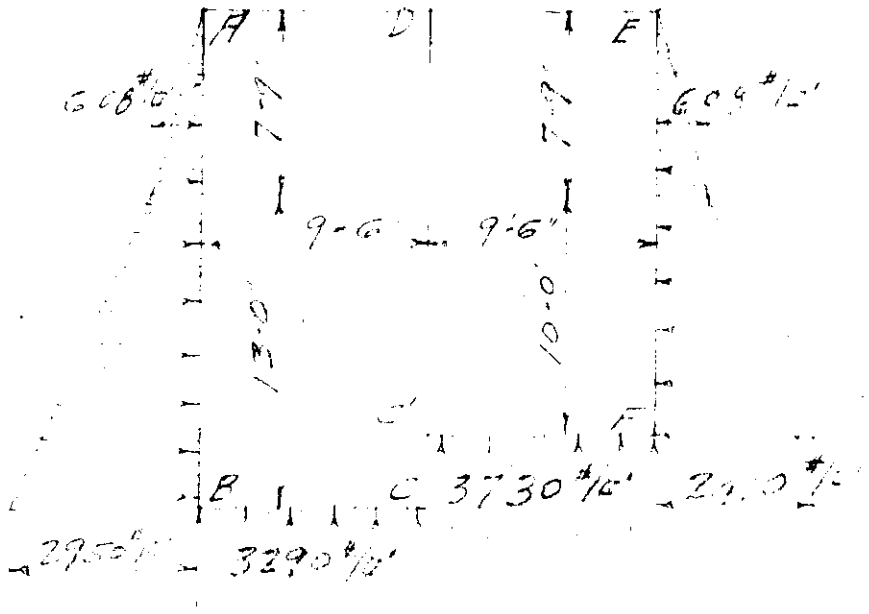
Page 76

Subject: Meadow Hill Pumping Station

Computation: Gate Chamber at Intake

Computed by: E.M.V. Checked by: Date: May 31, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Loading Diagram on Gate Chamber Frame.

Member	Length	Thickness	I	I/t	K.
A-B	240"	18"	7292"⁴	29	1.0
B-C	114	42"	74,035	632	22.4
C'-D	213	18"	7292	34	1.2
C'-F	114	33"	55,937	315	10.8
F-E	213	18"	7292	34	1.2
A-D	114	36	46,656	409	14.1
D-E	114	36"	46,656	409	14.1

Subject: Meadow Hill Pumping Station
Computation: Gate Chamber at Intake
Computed by: E. M. L. Checked by: Date: June 2, 1931

U. S. GOVERNMENT PRINTING OFFICE 3—10538

(Continued from sheet #74)

An inspection of the K-values on sheet #74 shows that the walls may be considered fixed top and bot. therefore

For member A-B, mom. at A" = 30,700#

" " B" = 53,400#

max. pos. mom. = 23,500#

max. shear = 19100 - 4900 = 14,200#

Max. design mom. = $53,400 - 19,100 \times 0.2 \times \frac{37.5}{12} = 41,400$#

Effective depth reqd = $\sqrt{\frac{41400 \times 12}{147 \times 15}} = 15.0$"

A_s at bot. = $\frac{41,400 \times 12}{\frac{7}{8} \times 15.0 \times 18000} = 2.1\square'' = \underline{3\text{-}1''\phi} @ 0.78\square'' = 2.34\square''$

A_s at top = $\frac{30,700 \times 12}{\frac{7}{8} \times 14.5 \times 18000} = 1.61\square'' = \underline{3\text{-}\frac{7}{8}''\phi} @ 0.60 = 1.80\square''$

A_s for pos. mom. = $\frac{23,500 \times 12}{\frac{7}{8} \times 14.5 \times 18000} = 1.23\square'' = \underline{3\text{-}\frac{3}{4}''\phi} @ 0.44 = 1.32\square''$

Use same steel for member E-F.

Use -3-$\frac{3}{4}$"ϕ bars in each face of mem C-D.

WAR DEPARTMENT

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Page 75

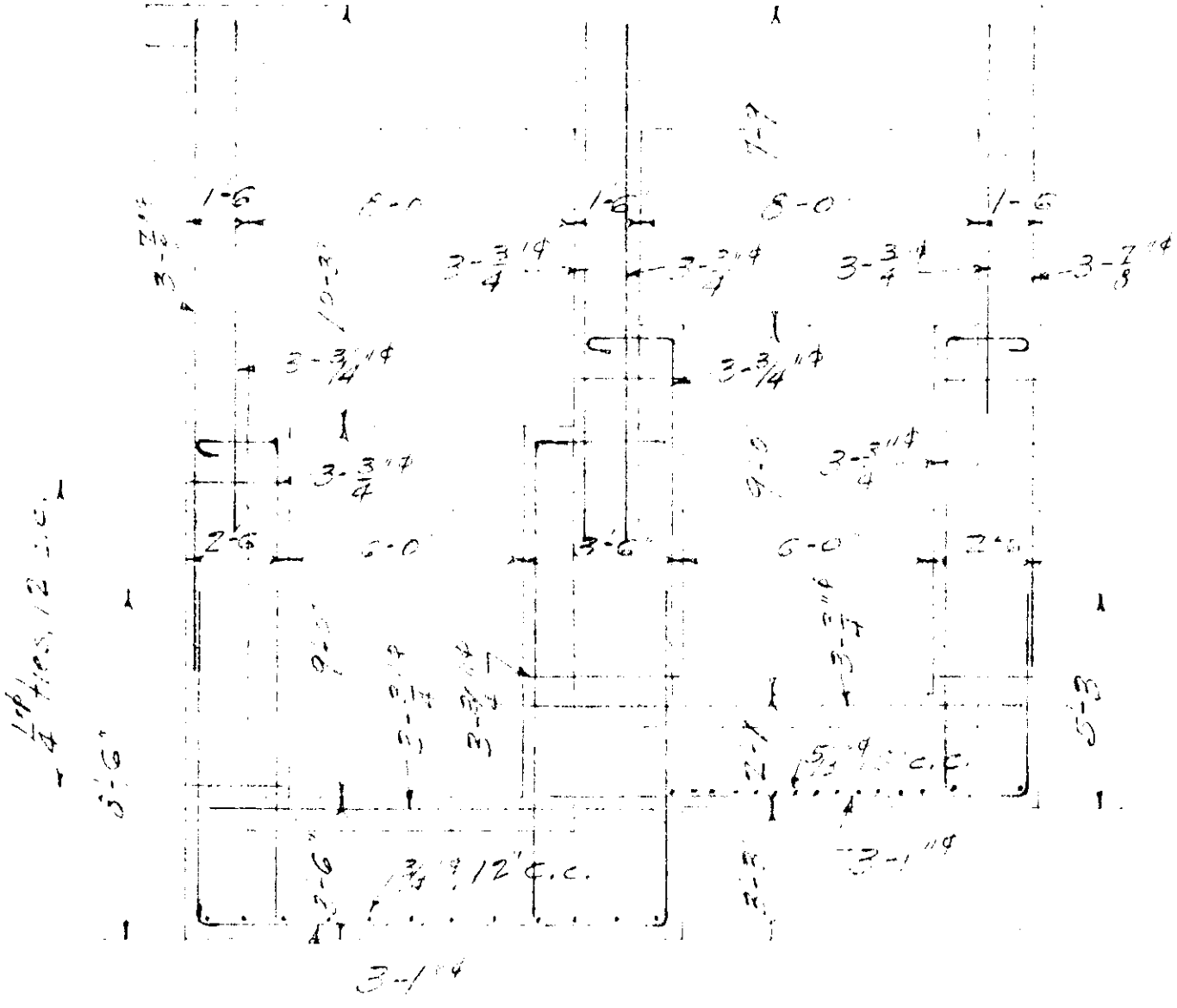
Subject Niagara Falls Pumping Station

Computation Gate Opener at Intake

Computed by E.M.V. Checked by Date June 2, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continuation from sheet #75)



WAR DEPARTMENT

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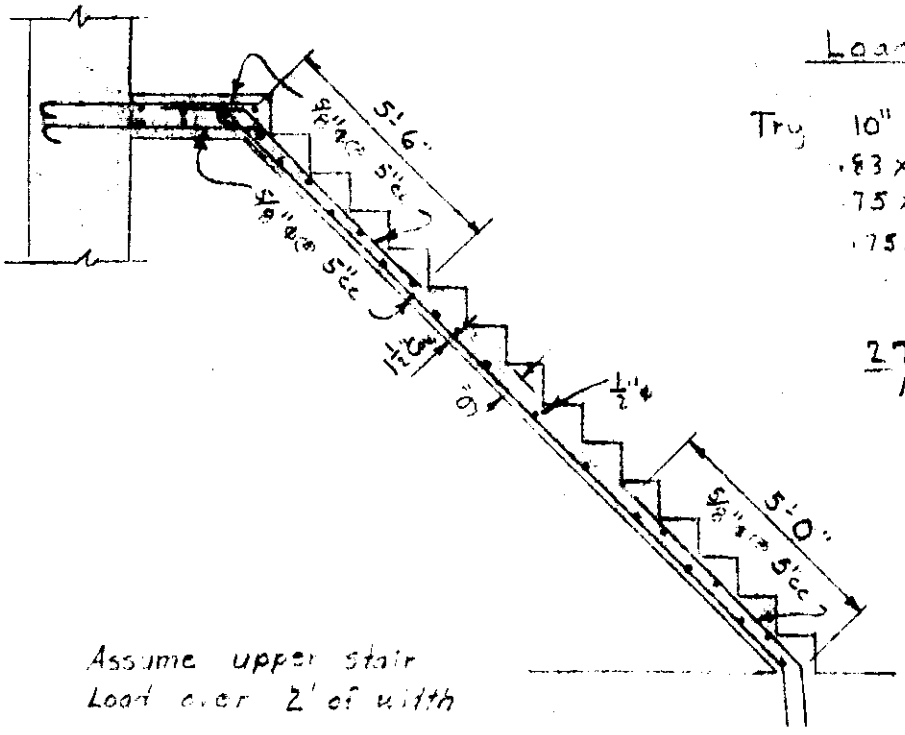
Page 79

Subject Meadow Hill Pumping Station

Computation Wet Sump stairway

Computed by H.E.W. **Checked by** **Date** 5/13/41

U. S. GOVERNMENT PRINTING OFFICE 3—10638



Loads

Try 10" slab

.83 x 14.5 x 150	=	1,800
.75 x 3 x 150	=	340
.75 x .75 x 14/2 x 150	=	590
		2730

$\frac{2730}{13.5} + 50 = 250$ #/'

$R_L = \frac{(250)(13.5)(6.75) + (465)(3)(12)}{13.5}$

$R_L = 2930$ #

Pt. of Max Mom.

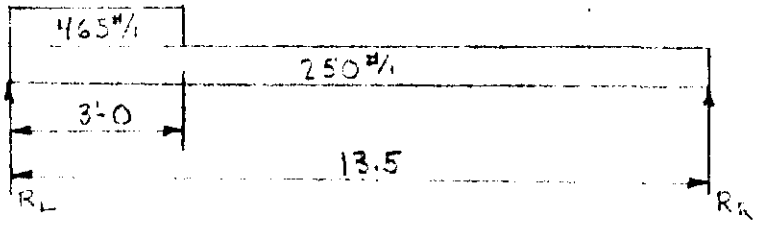
$2930 - 465 \times 3 = 250 X_0$

$X_0 = 6.15$

$M = 2930 \times 6.15 - (465)(3)(1.65) - 250 \times 6.15 \times 3.08$

$M = 6.750$ '#

Assume upper stair Load over 2' of width



Depth req'd = $\sqrt{\frac{6750}{23}}$ = 7.4"

Use 9" slab d = 7.4

$A_s = \frac{6750 \times 12}{\frac{7}{8} \times 7.4 \times 18000} = .65$ □" Use $\frac{5}{8}$"ø @ 5"cc

Unit shear $\frac{2930}{12 \times \frac{7}{8} \times 7.4}$ = 38 #/□"

Bond stress = $\frac{2930}{4.7 \frac{7}{8} \times 7.4}$ = 96 #/□"

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

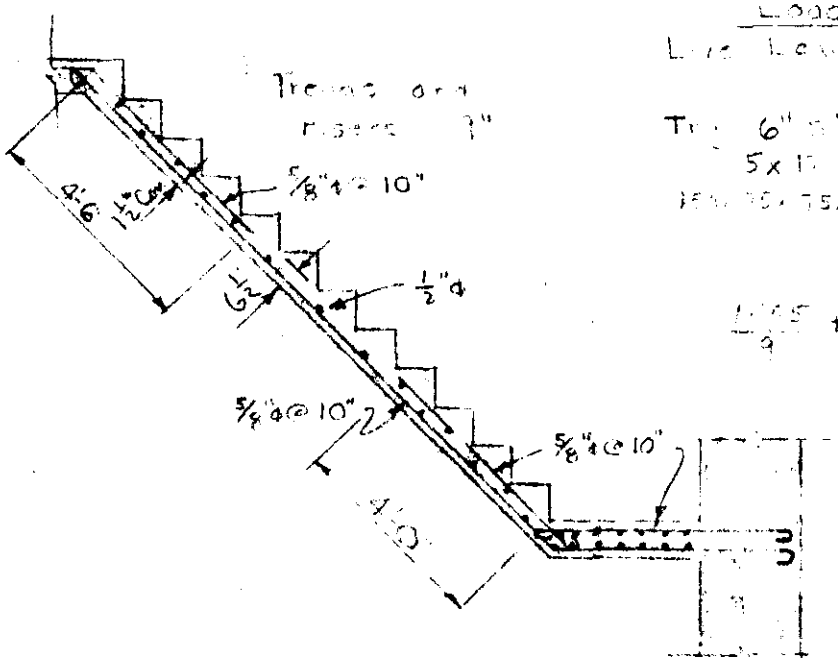
Page 80

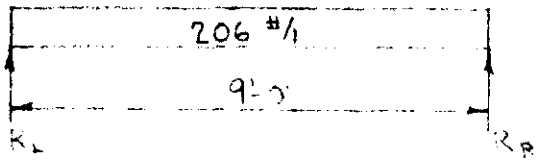
Subject Meadow Hill Pumping Station

Computation Wet Sump Stairway

Computed by H. E. W. **Checked by** ..... **Date** 5/17/41

U. S. GOVERNMENT PRINTING OFFICE 3—10528





Loads

Live Load = 50 #/1

Try 6" slab

5 x 12 x 150 = 900

150 x 75 x 75 x 2 x 12 = 500

1405

$\frac{1405}{9}$ + 50 = 206 #/1

M = [illegible] = 2100 #

Reqd = $\sqrt{\frac{2100}{120}}$ = 4.1"

Use 6 1/2 slab d = 4.4"

R_R = [illegible] = 930 #

$A_s = \frac{2,100 \times 12}{\frac{7}{8} \times 4.4 \times 18000}$ = .37 □" use 5/8"φ @ 10" cc

Unit shear = $\frac{930}{12 \times \frac{7}{8} \times 4.4}$ = 26 #/□"

Bond stress = $\frac{930}{2.35 \cdot \frac{7}{8}(4.4)}$ = 103 #/□"

WAR DEPARTMENT

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Page 81

Subject

Computation

Computed by Checked by Date

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WAR DEPARTMENT

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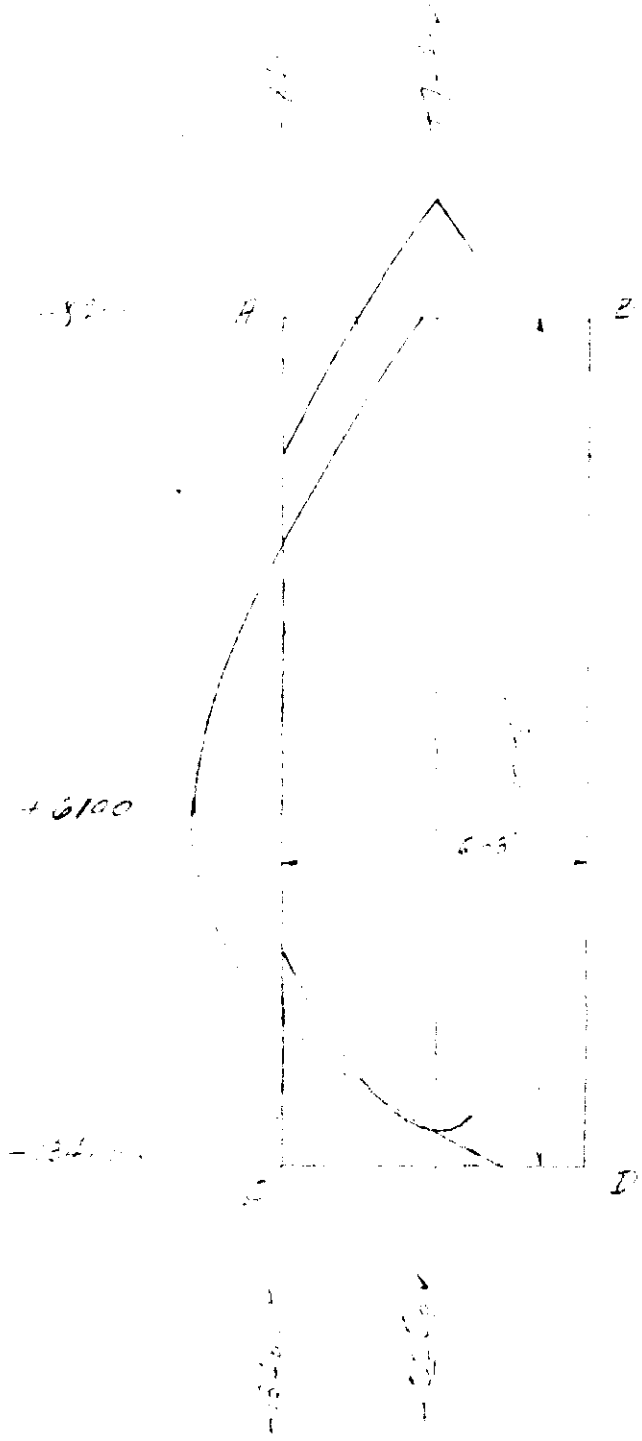
Page

Subject

Computation

Computed by Checked by Date

U. S. GOVERNMENT PRINTING OFFICE 3—10526



WAR DEPARTMENT

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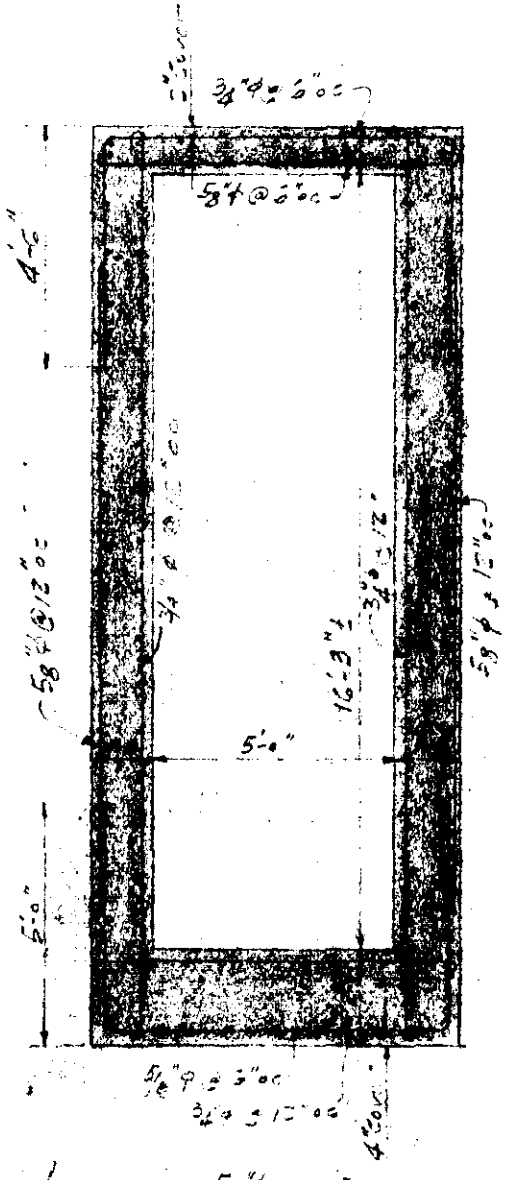
Page 83

Subject [illegible]

Computation Rock [illegible]

Computed by [illegible] Checked by [illegible] Date [illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10628



Bars not marked 5/8"φ @ 12" o.c.
Cover 3" except as noted.

WAR DEPARTMENT

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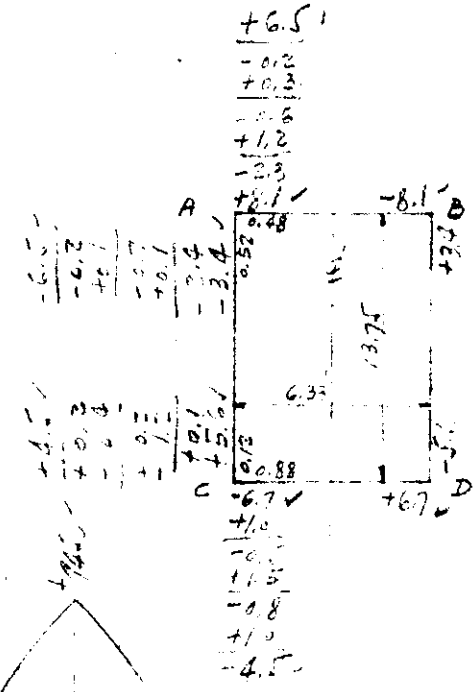
Page 84

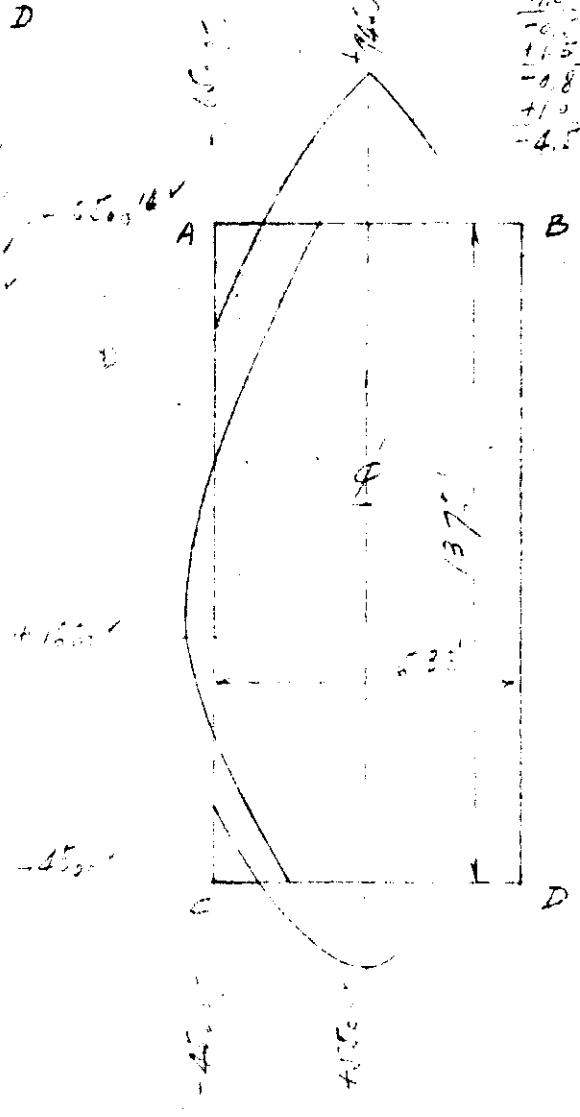
Subject [illegible]

Computation [illegible]

Computed by [illegible] Checked by [illegible] Date 5-29-41

U. S. GOVERNMENT PRINTING OFFICE 3—10538





WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 8[illegible]

Subject Memorial Bridge Sta. [illegible]

Computation Sanitary Sewer Intake

Computed by W. W. Z. **Checked by** [illegible] **Date** 5-[illegible]-4[illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Member AB

$-A_s = \frac{6500 \times 12}{7/8 \times 18000 \times 8.5} = 0.58^{\square''}$ ✓

$+A_s = \frac{9450 \times 12}{7/8 \times 18000 \times 9.5} = 0.7[illegible]^{\square''}$ ✓

$v = [illegible]$

Member CD

$-A_s = \frac{4500 \times 12}{7/8 \times 18000 \times 17.5} = 0.18^{\square''}$ ✓

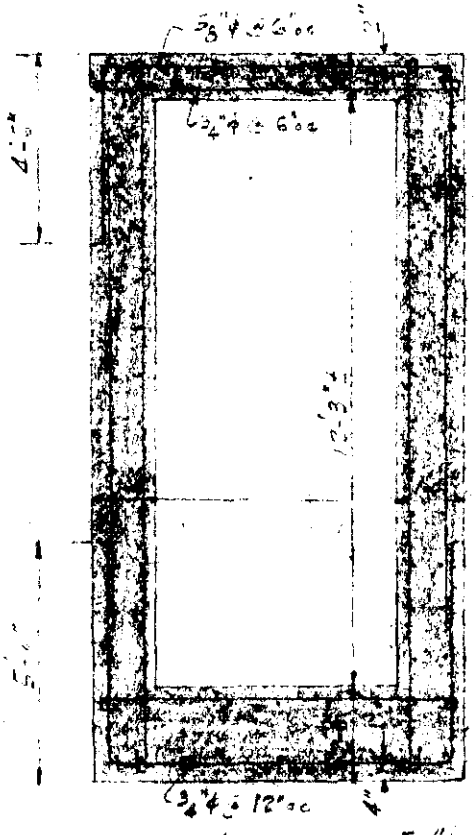
$+A_s = \frac{5500 \times 12}{7/8 \times 18000 \times 20} = 0.20^{\square''}$ ✓

Member AC

$-A_{s_1} = \frac{6500 \times 12}{7/8 \times 18000 \times 12.5} = 0.40$ ✓

$-A_{s_2} = \frac{4500 \times 12}{7/8 \times 18000 \times 12.5} = 0.28^{\square''}$ ✓

$+A_s = \frac{1660 \times 12}{7/8 \times 18000 \times 12.5} = [illegible]^{\square''}$ ✓



Bars not marked 5/8"φ @ 12" oc
Cover 3" [illegible]

WAR DEPARTMENT

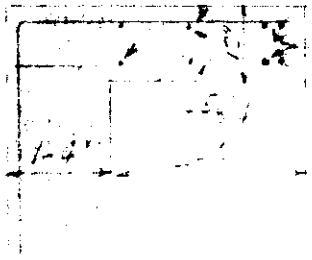
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject

Computation

Computed by Checked by Date

U. S. GOVERNMENT PRINTING OFFICE 3—10523



4-$\frac{5}{8}$"

WAR DEPARTMENT

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Subject Meadow Hill [illegible] Sta. EL 6[illegible]

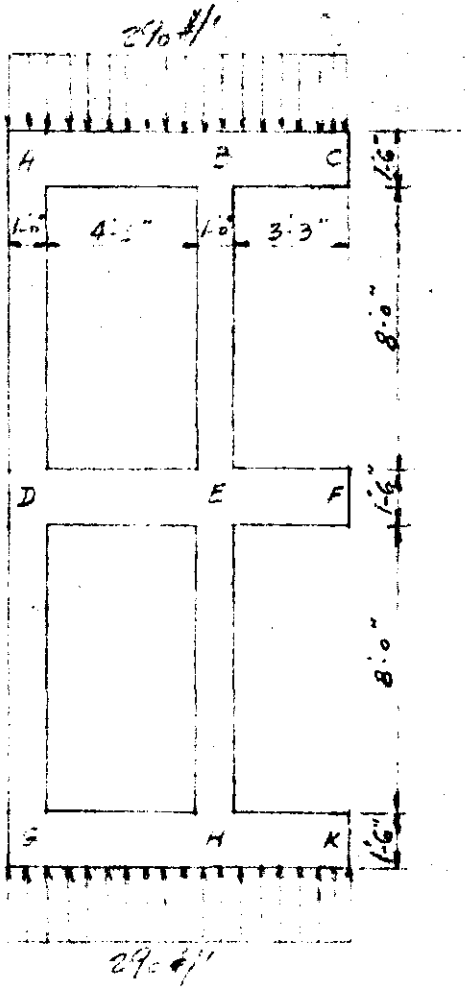
Computation [illegible]

Computed by [illegible] Checked by [illegible] Date 5-8-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Horizontal [illegible] @ EL. 10.0

35# × 8.25 = 290 #/'



Note

Using High Water EL 10.0 as a dividing line the intake structure above EL 10.0 will be designed as a horizontal section, whereas the structure below EL 10.0 will be designed as a transverse vertical section.

AB - DE - GH	18"	583[illegible]	6[illegible]"	[illegible]	[illegible] ✓
BC - EF - HK	18"	cantilever	4[illegible]"		
AD - DG - BE - EH	12"	1728	11[illegible]"	15.2	1.0 ✓

WAR DEPARTMENT

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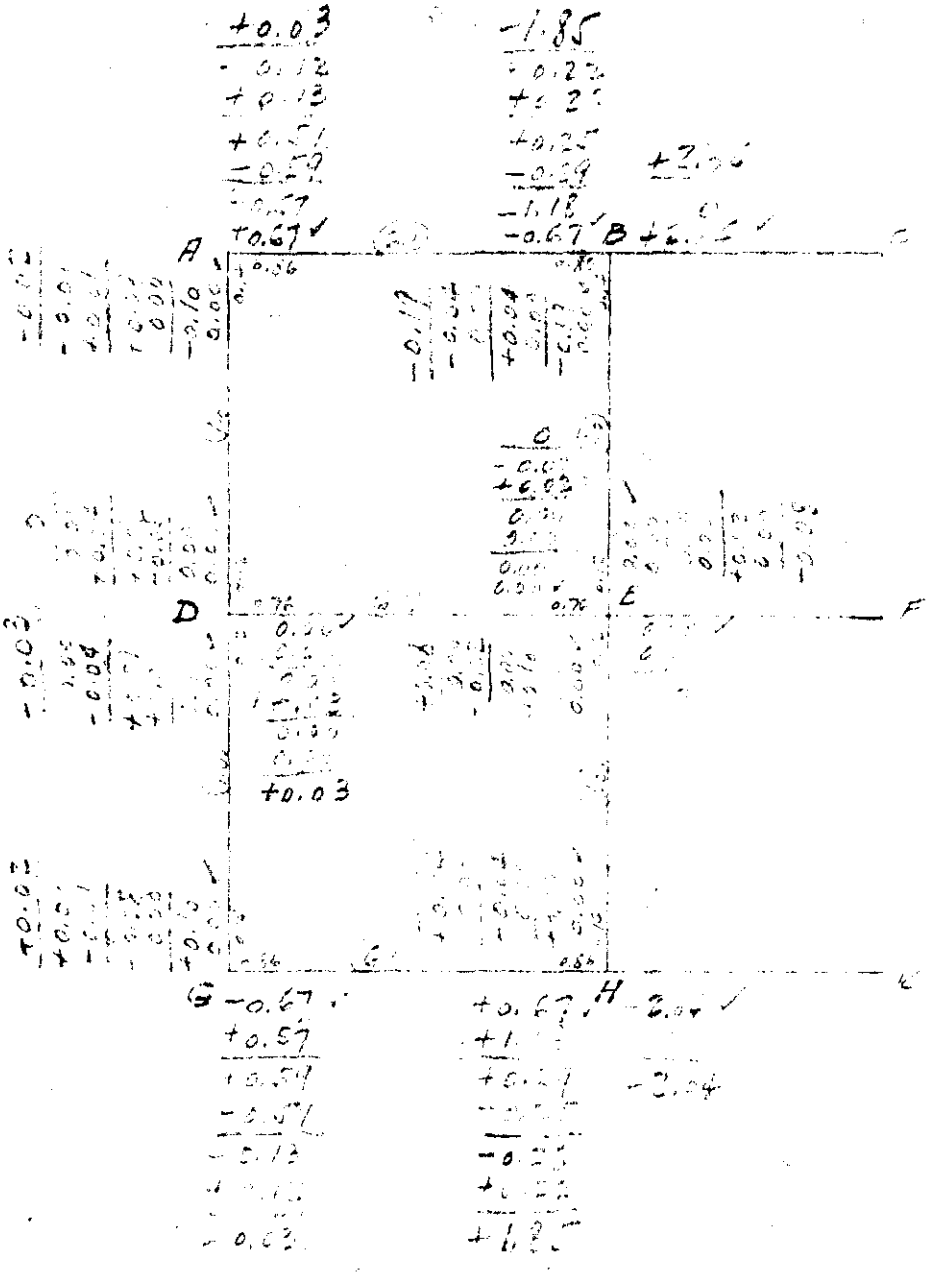
Page 88

Subject Meadow Hill Pumping Sta. Ft. [illegible]

Computation Intake Structure

Computed by W. W. Z. Checked by [illegible] Date 5-8-[illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10538



Moment Distribution

for Horizontal Section

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

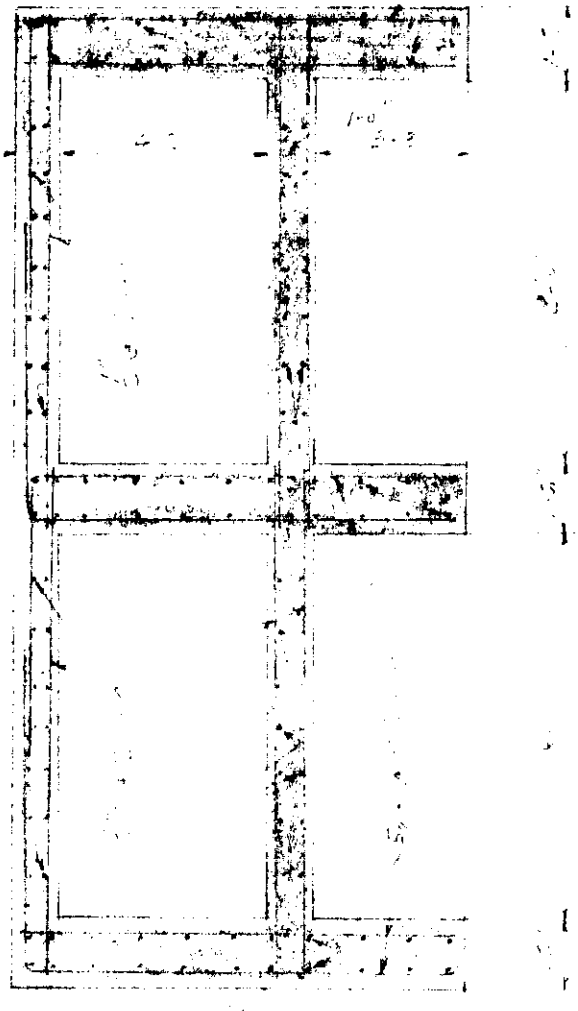
Page

Subject

Computation

Computed by **Checked by** **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10528



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

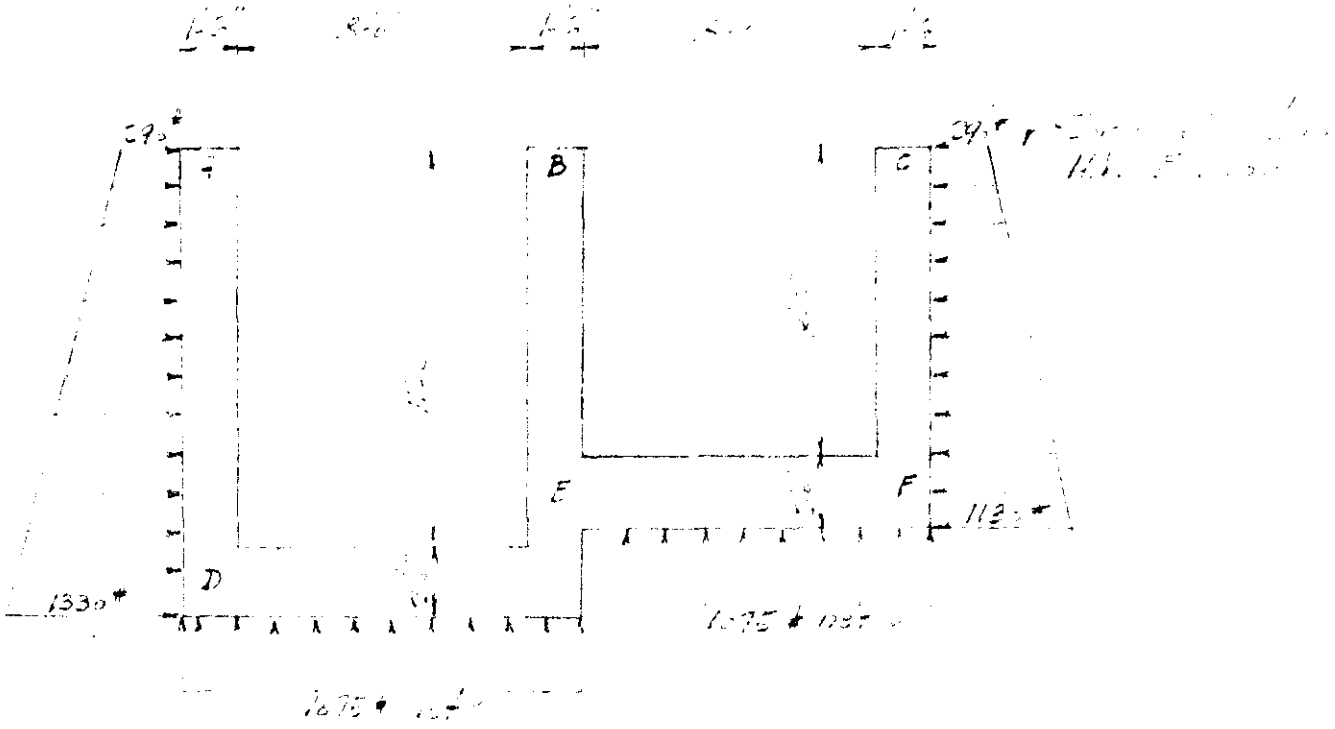
Page [illegible]

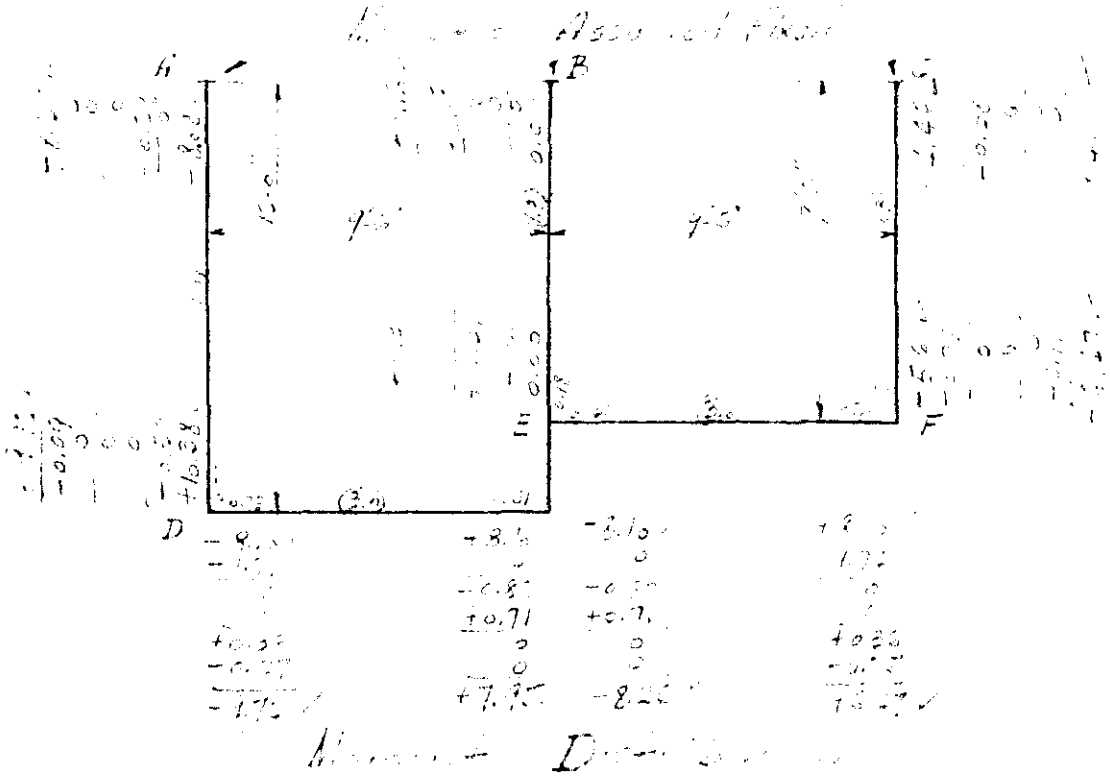
Subject [illegible]

Computation [illegible]

Computed by [illegible] **Checked by** [illegible] **Date** [illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10528



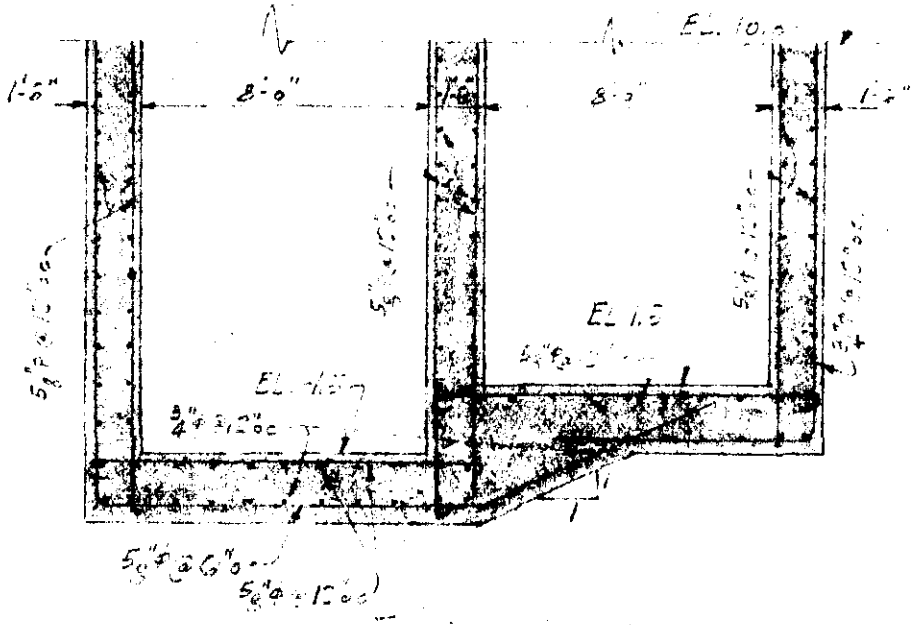


Subject

Computation

Computed by **Checked by** **Date**

U. S. GOVERNMENT PRINTING OFFICE



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

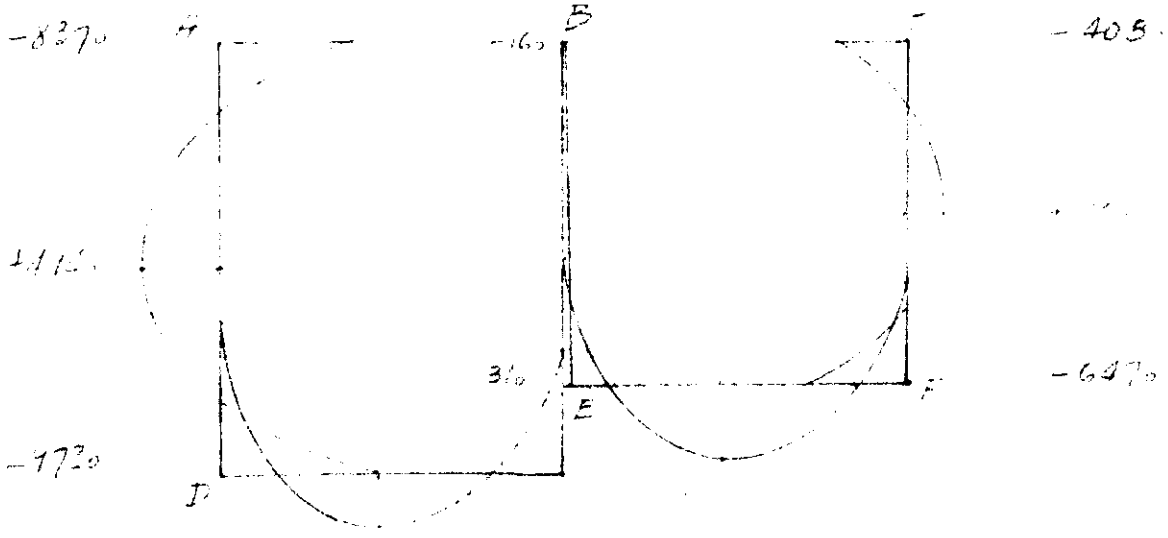
Page 92

Subject [illegible]

Computation [illegible]

Computed by [illegible] Checked by [illegible] Date [illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10528



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject: Meadow Hill Pumping Sta. EH 60

Computation: Intake Structure

Computed by: W. W. Z. Checked by: [illegible] Date: [illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10628

Member AD

$d = \sqrt{\frac{9720}{147}} = 8.2''$ Use 18 (16) - 3[illegible] = [illegible]"

$-A_{s_1} = \frac{9720 \times 12}{7/8 \times 18000 \times 12.5} = 0.59 \square''$

$-A_{s_2} = \frac{8370}{9720} \times 0.59 = 0.51 \square''$

$+A_s = \frac{4940 \times 12}{7/8 \times 18000 \times 12.5} = 0.30 \square''$

$v = \frac{5690}{7/8 \times 12 \times 12.5} = 45 \#/\square''$

Member CF

Use d = 19.5 (12.5)"

$-A_{s_1} = \frac{6470 \times 12}{7/8 \times 18000 \times 12.5} = 0.39 \square''$

$-A_{s_2} = \frac{4460}{6470} \times 0.39 = 0.27 \square''$

$+A_s = \frac{2200 \times 12}{7/8 \times 18000 \times 12.5} = 0.14 \square''$

Member DE

$-A_{s_1} = \frac{9720 \times 12}{7/8 \times 18000 \times 20.5} = 0.36 \square''$

$-A_{s_2} = \frac{7950}{9720} \times 0.36 = 0.3[illegible] \square''$

$+A_s = \frac{3100 \times 12}{7/8 \times 18000 \times 19.5} = 0.12 \square''$

Member EF

$-A_{s_1} = \frac{6[illegible]}{7/8 \times 18000 \times [illegible]} = 0.31 \square''$

$-A_{s_2} = \frac{6470}{8[illegible]} \times 0.31 = 0.24 \square''$

$+A_s = \frac{4[illegible]}{7/8 \times 18000 \times 20.5} = 0.[illegible] \square''$

Member BE -

Max. Neg. Moment = 3[illegible]'#

No [illegible]

Use nominal steel ✓

WAR DEPARTMENT

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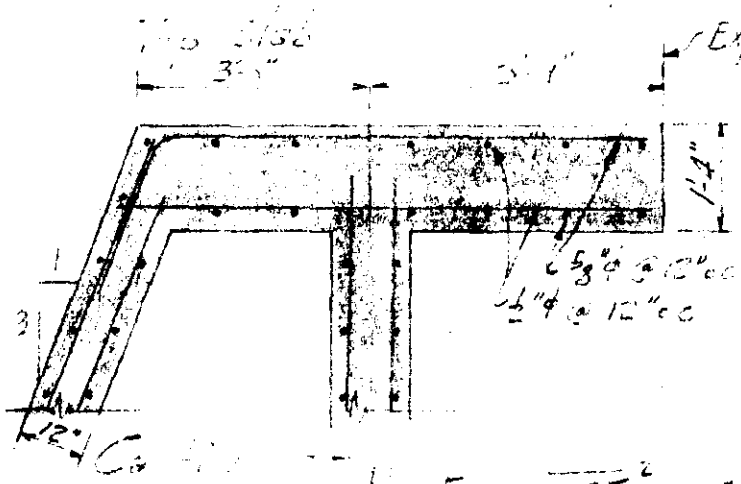
Subject [illegible]

Computation [illegible]

Computed by [illegible] Checked by [illegible] Date [illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10528



$M = 500 \times \overline{5.75}^2 = 35[illegible]$

$d = \sqrt{\frac{35[illegible]}{167}} = 4.[illegible]"$ [illegible]

$A_s = \frac{35[illegible] \times [illegible]}{[illegible] \times 18[illegible] \times 13.5} = 0.[illegible]$ [illegible]

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

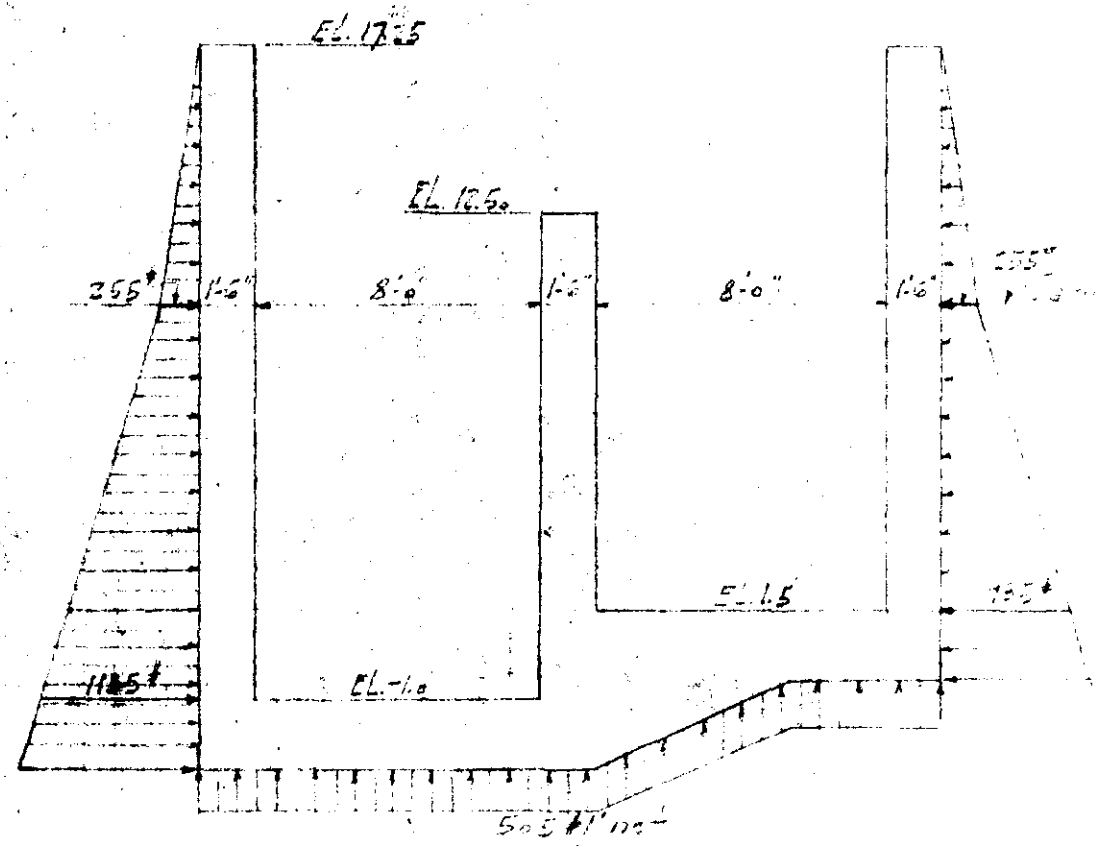
Page 95

Subject Meadow Hill Pumping Sta.

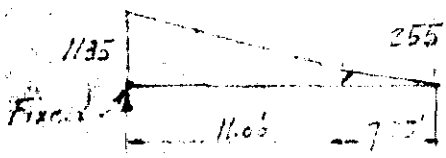
Computation Intake Retaining Wall

Computed by W. W. Z. **Checked by** [illegible] **Date** [illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10633



Moment in left wall - (Cantilever)



$\frac{1}{2} \times 255 \times 7.25 = 924\# \times 15.42 = 12400'\#$

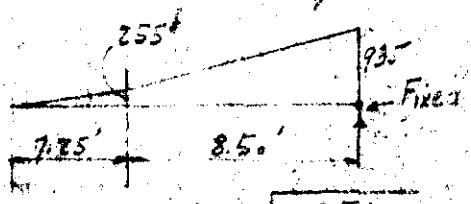
$255 \times 11.0 = 2810\# \times 5.50 = 15450$

$\frac{1}{2} \times 880 \times 11.0 = 4840\# \times 3.67 = 17750$

$8574\#$ $\quad$ $45600'\#$

$$\text{Req. } d = \sqrt{\frac{45600}{123}} = 19.3'' \quad \text{Use } d = 24'' - 3\tfrac{1}{2} = 20.5''$$

Moment in right wall - (Cantilever) -



$\frac{1}{2} \times 255 \times 7.25 = 924\# \times [illegible] = 10100'\#$

$255 \times 8.50 = 2170\# \times 4.[illegible] = [illegible]$

$\frac{1}{2} \times 680 \times 8.50 = 2880\# \times [illegible] = [illegible]$

$5984\#$ $\quad$ $27510'\#$

$$\text{Req. } d = \sqrt{\frac{27510}{123}} = 15.0'' \quad \text{Use } d = [illegible]$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

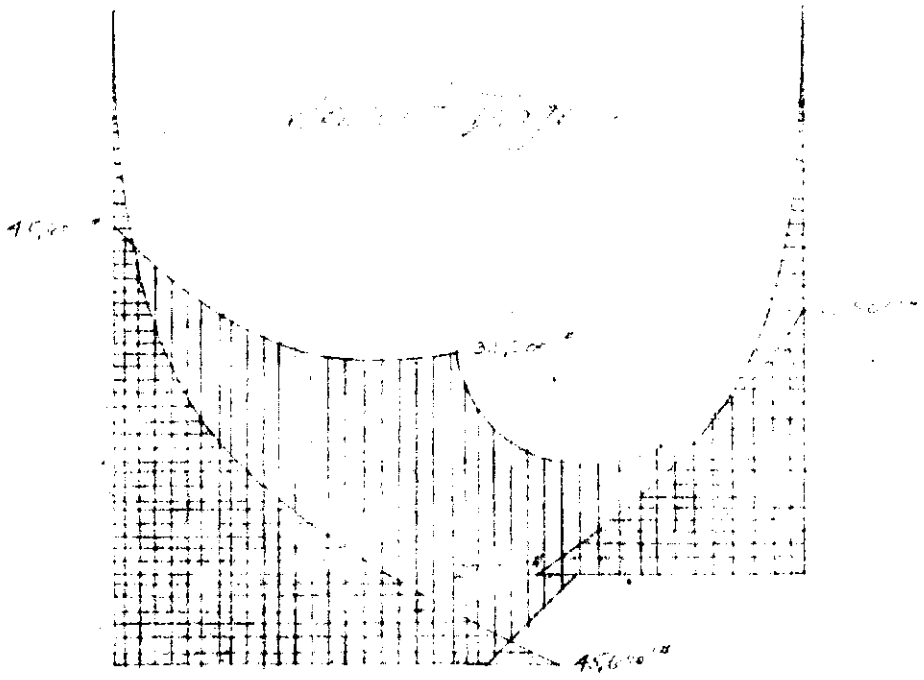
Page 96

Subject [illegible]

Computation [illegible]

Computed by [illegible] Checked by [illegible] Date [illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Steel [illegible]

A_s = [illegible] = [illegible]

Steel at [illegible]

A_s = [illegible] = [illegible]

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

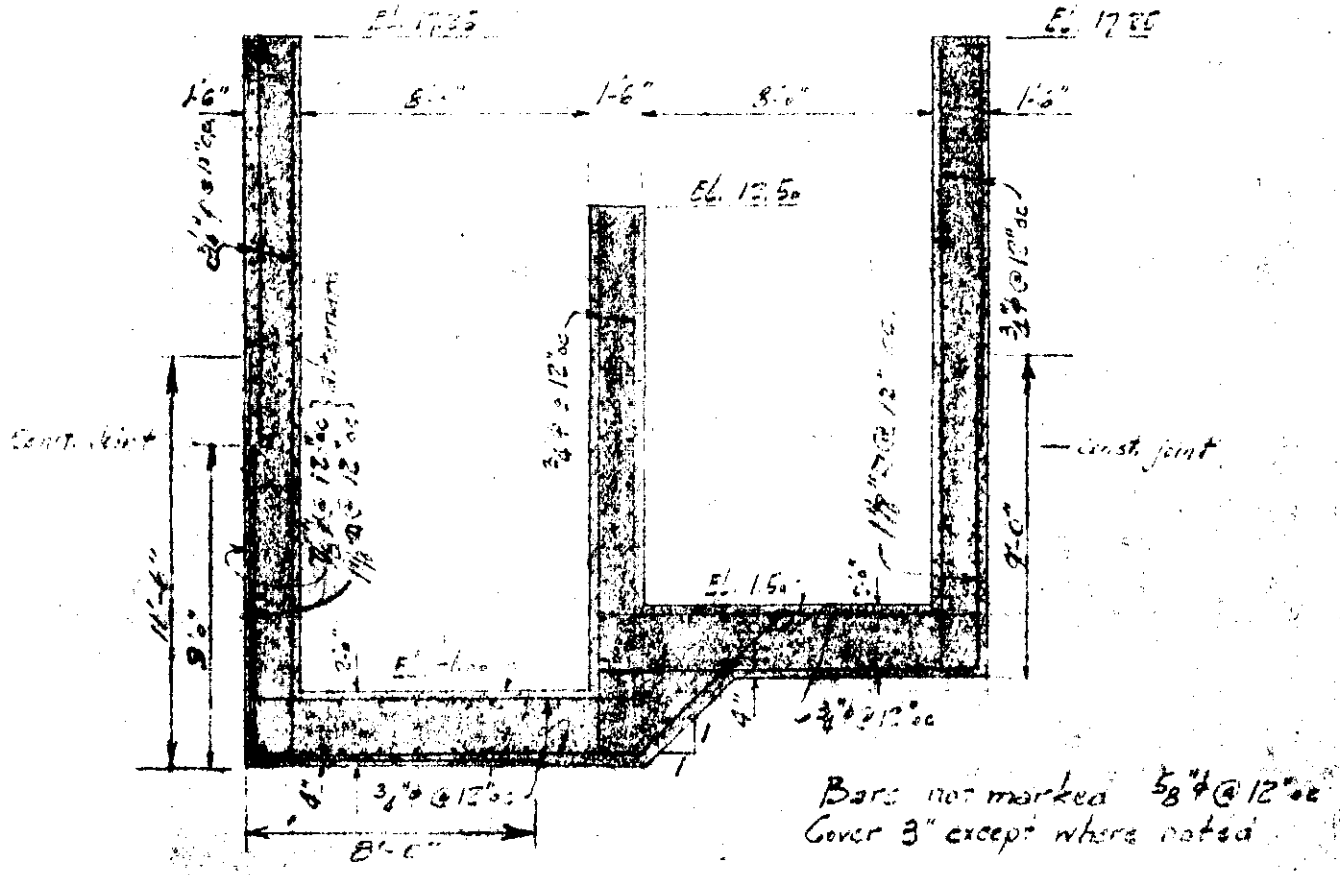
Page 97

Subject [illegible]

Computation [illegible]

Computed by [illegible] Checked by [illegible] Date 5-12-41

U. S. GOVERNMENT PRINTING OFFICE 3—30636



WAR DEPARTMENT

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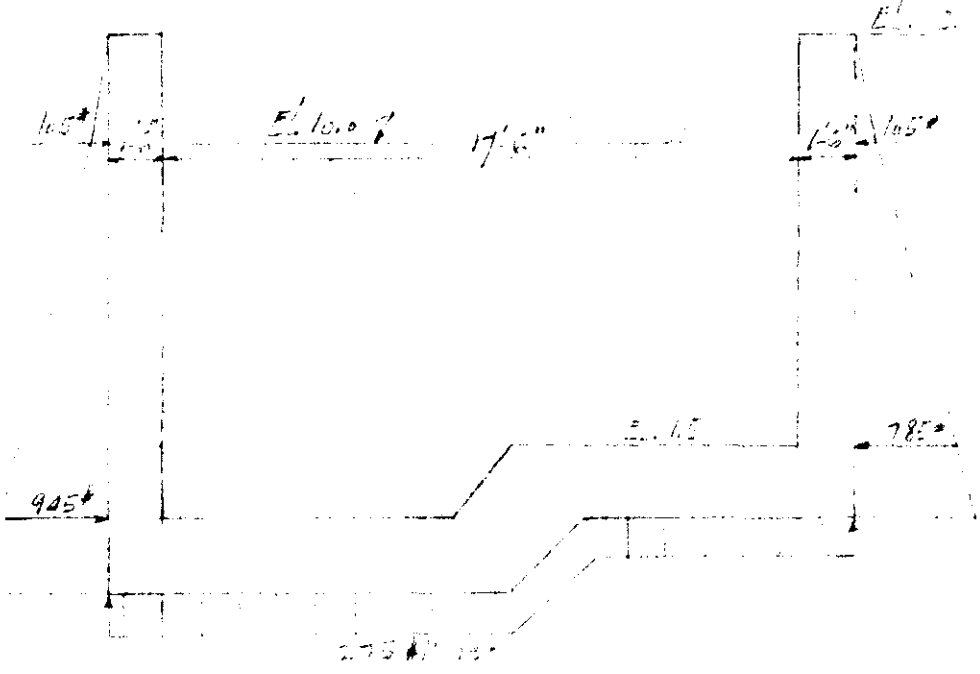
Page 98

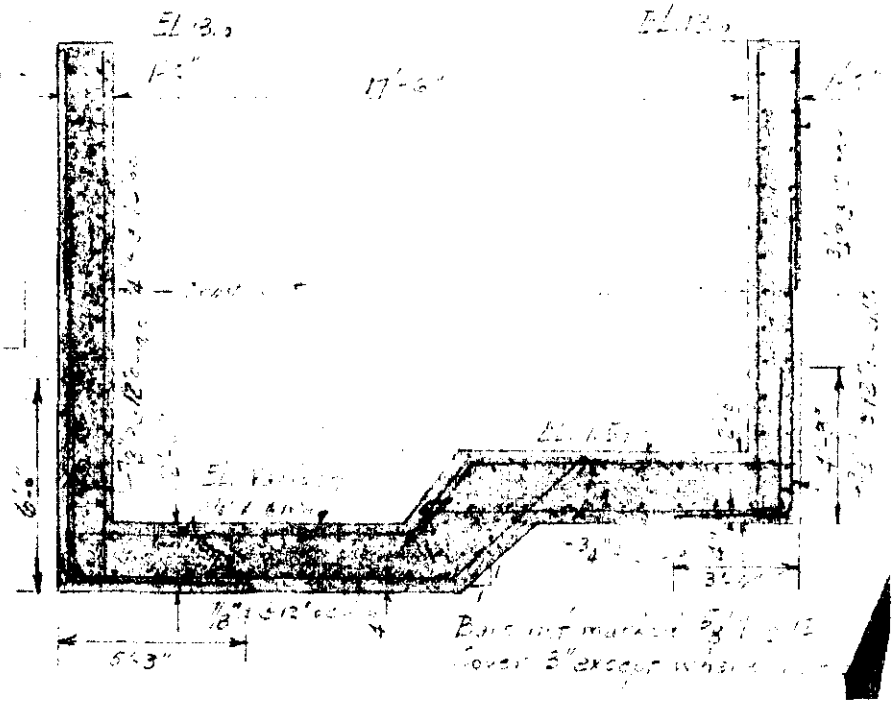
Subject [illegible]

Computation [illegible]

Computed by W. W. Z. **Checked by** [illegible] **Date** 5-12-41

U. S. GOVERNMENT PRINTING OFFICE 3—16528





WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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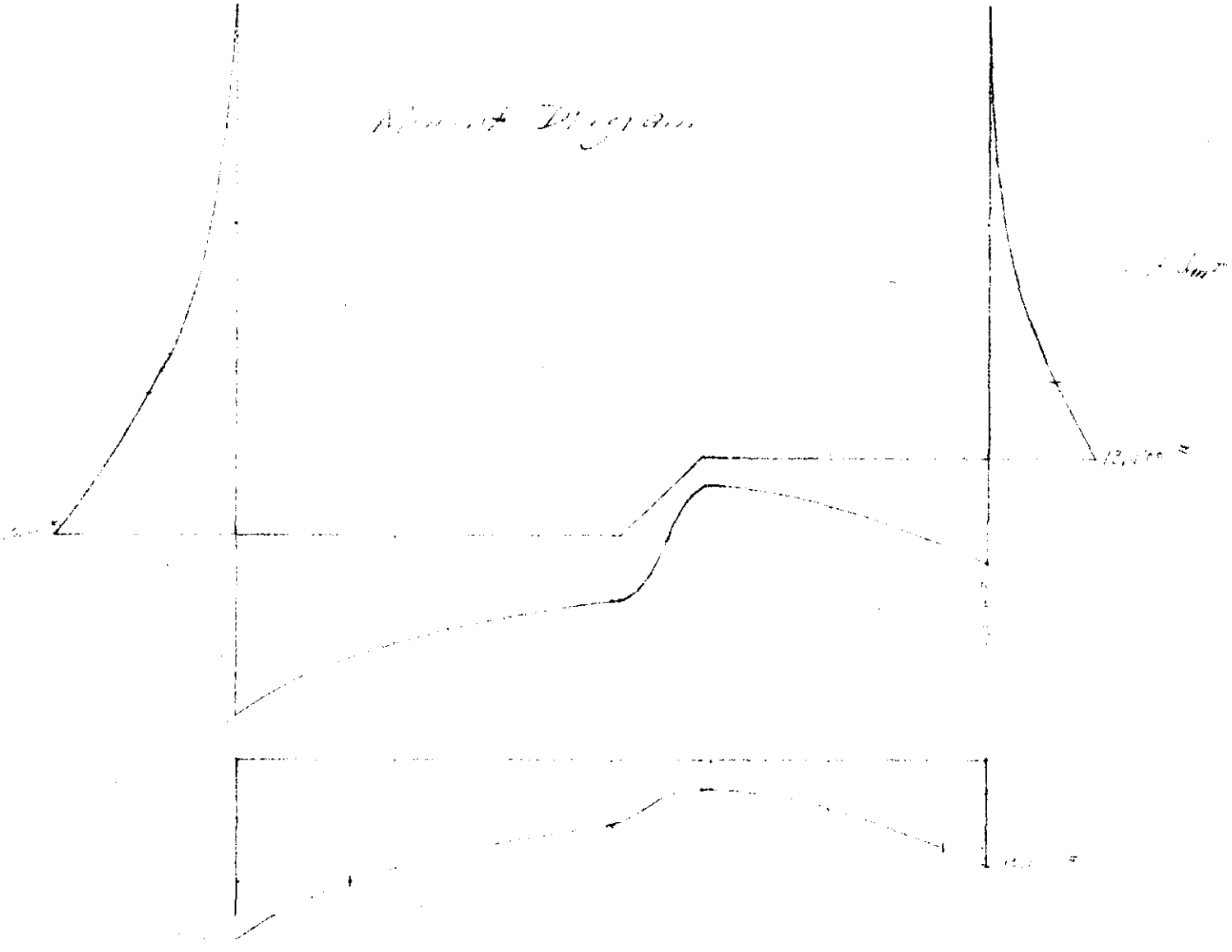
Subject Meadow Hill Pumping Station

Computation Inlet Tertiary

Computed by W.W.Z. & W.O.Sp. Checked by _____ Date June 14, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10888



WAR DEPARTMENT

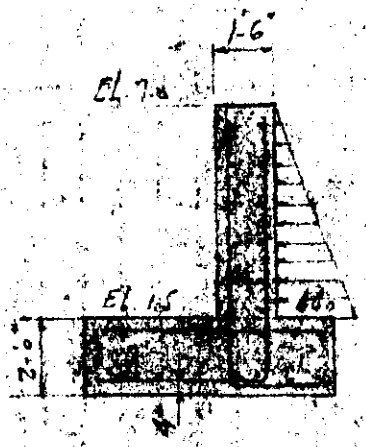
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Sta.

Computation Inlet Portal Retaining Walls

Computed by W. W. Z. **Checked by** [illegible] **Date** 5-13-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Stem moment = [illegible] × 44 × 5.5² × ⅓ = 2320 ft

Make all bars 5/8" [illegible]

Cover 3" except [illegible]

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 101

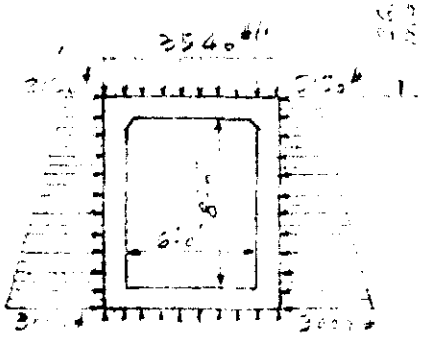
Subject Meadow Hill Pumping Sta EH 6c

Computation Discharge Conduit (under Dike)

Computed by [illegible] **Checked by** [illegible] **Date** 5-13-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Conduit Empty

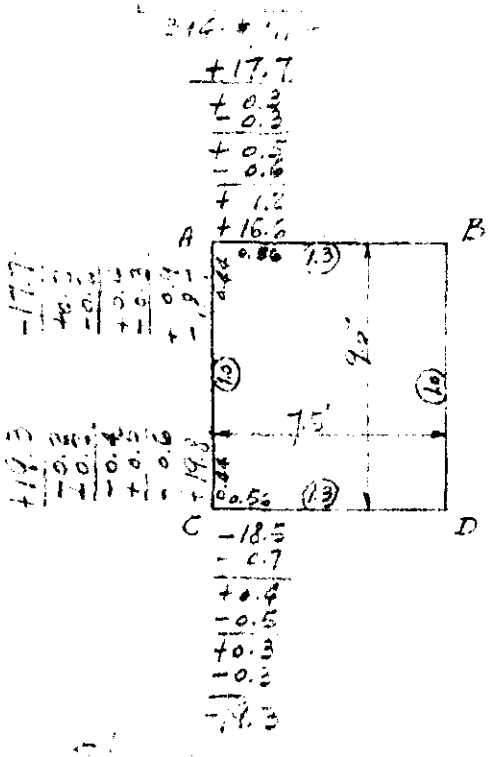


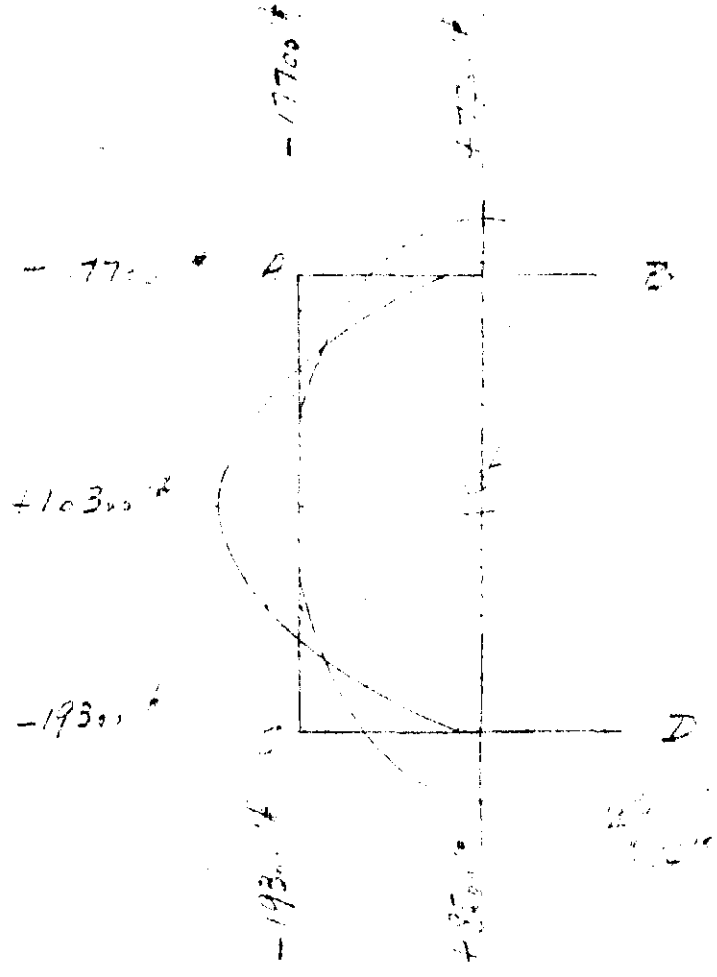
Assume Earth Dike saturated
Assume Conduit 1'6" thick

26.5 × 125 = 3310 #/'
.5 × 150 = 225
3540 #/'

3540 × 1 = 3[illegible]
2×8×1.5 × 150 = [illegible]
3540 × 1/7 = 392[illegible] #/'

26.5 × 80 = 21[illegible] #
11.0 × 80 = 88[illegible]
3[illegible] #





Shears
AB @ A = 13300 # ✓
CD @ C = 14800 # ✓
AC @ A = 11380 # ✓
@ C = 12920 # ✓
Positive Moments
AB = 7200 '# ✓
CD = 6700 '# ✓
AC = 10300 '# ✓

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 102

Subject [illegible]

Computation [illegible]

Computed by [illegible] Checked by [illegible] Date [illegible]

U. S. GOVERNMENT PRINTING OFFICE 2-10528

Member AB

$v = \frac{[illegible]}{7/8 \times 12 \times 14.5} = 87\#/\square''$ $\quad a = \sqrt{\frac{[illegible]}{14.5}} = 11''$

$-A_s = \frac{[illegible] \times 12}{7/8 \times 18000 \times 14.5} = 0.93\square''$ $\quad$ use $d = 18 - 3.5 = 14''$

$+A_s = \frac{[illegible] \times 12}{7/8 \times 18000 \times 14.5} = 0.35\square''$

Shear intensity at edge of wall with 6" [illegible] -

$v = \frac{[illegible]}{7/8 \times 12 \times 30.5} = 50\#/\square''$

Member AC

$v = \frac{12930}{7/8 \times 12 \times 14.5} = 85\#/\square''$ $\quad a = 14.5''$

[illegible]

$v = \frac{10750}{7/8 \times 12 \times 14.5} = 70\#/\square''$

$-A_{s_1} = 0.93\square''$ $\quad +A_s = \frac{10300 \times 12}{7/8 \times 18000 \times 14.5} = 0.52\square''$

$-A_{s_2} = \frac{19300 \times 12}{7/8 \times 18000 \times 14.5} = 1.02\square''$

Member CD

for shear $d = \frac{14800}{60 \times 7/8 \times 12} = 23.5''$ $\quad$ use $d = 24 - 4.5 = 19.5''$

$v = \frac{14800}{7/8 \times 12 \times 19.5} = 72\#/\square''$

$-A_s = \frac{19300 \times 12}{7/8 \times 18000 \times 19.5} = 0.76\square''$

$+A_s = \frac{8500 \times 12}{7/8 \times 18000 \times 30.5} = 0.32\square''$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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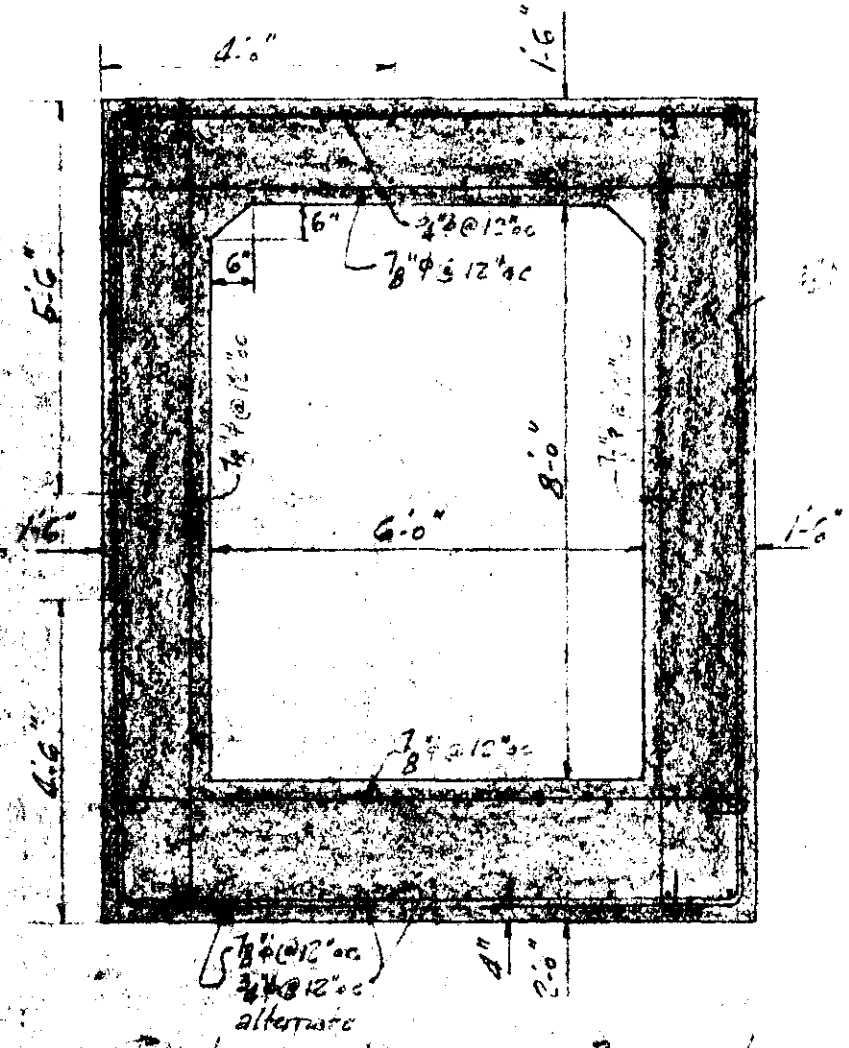
Subject [illegible]

Computation Distance [illegible]

Computed by W. H. [illegible] Checked by ..... Date [illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10698



Scale 3/8" = 1'-0"

Bars not marked 5/8"φ @ 12" o.c.
Cover 3" except where noted

Section through center of disc

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

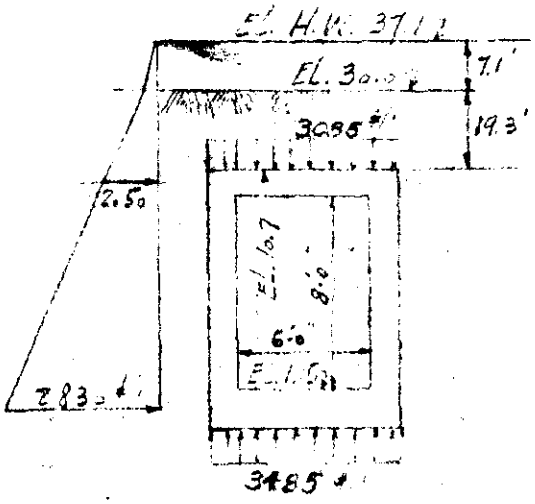
Page 104

Subject Meadow Hill Pumping Sta. EL [illegible]

Computation Discharge Conduit

Computed by [illegible] **Checked by** [illegible] **Date** [illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10528



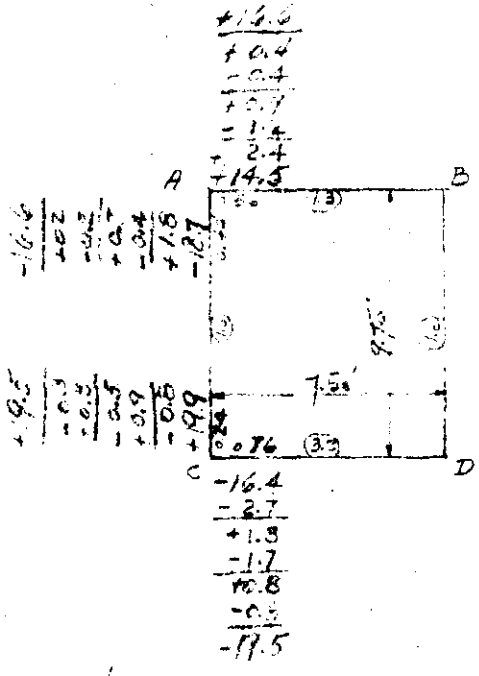
Conduit assumed empty
High Water @ EL. 37.1
Earth cover (subbing) [illegible] EL. 30.0

Loading on top [illegible]
62.5 × 7.1' = 445 #
125 × 19.3 = 2415
Slab wgt = 225
3085 #

Side Wall Pressures –
at top [illegible]
62.5 × 7.1 = 445
8.0 × [illegible] = 505
2050 #

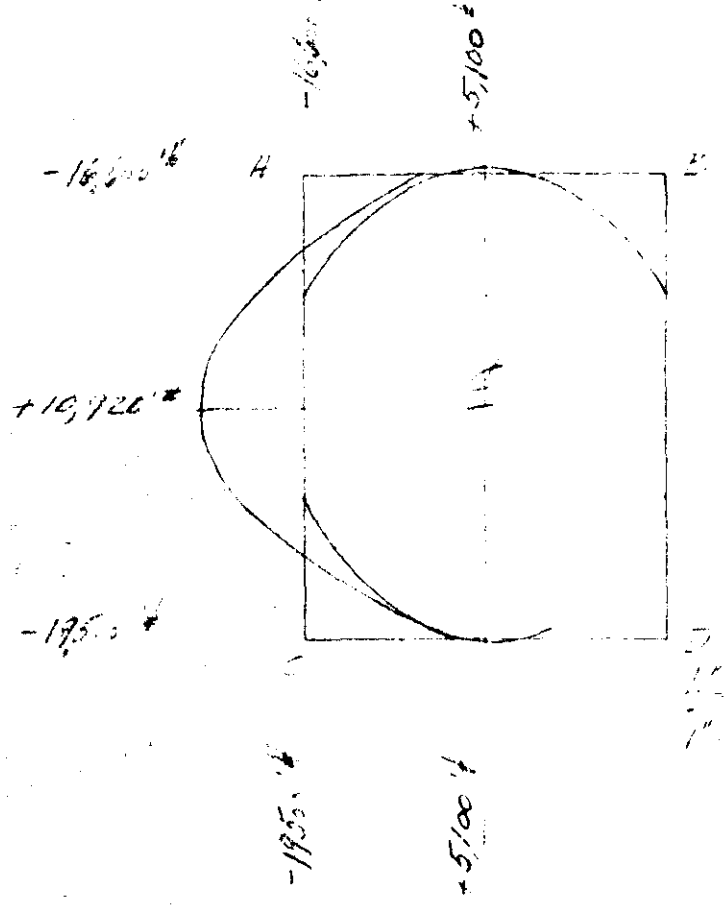
at [illegible]
[illegible]

Net Pressure [illegible]
3085 + 2 × 2 × 225 = 3485 #



Shears –
AB @ A = 11,600 #
CD @ C = 13,100 #
AC @ A = 10,970 #
@ C = 12,830 #

Pr. Moments –
AB = +5,100 '#
CD = +5,100 '#
AC = +10,920 '#



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 105

Subject [illegible] EH 6[illegible]

Computation Discharge Conduit

Computed by [illegible] Checked by [illegible] Date 5-14-41

U. S. GOVERNMENT PRINTING OFFICE 3—10536

Member AB

$v = \frac{11,600}{7/8 \times 12 \times 14.5} = 76\ \#/\square''$

$-A_s = \frac{16,600 \times 12}{7/8 \times 18[illegible] \times 14.5} = 0.87\ \square'' - 2\text{-}3/4''\phi @ 0.44 = 0.88\ \square''$

$+A_s = \frac{5,[illegible] \times 12}{7/8 \times 14.5 \times 18,[illegible]} = 0.27\ \square''$

$u = \frac{11,600}{2 \times 2.36 \times 7/8 \times 14.5} = 193\ \#/\square''$

Member CD

$v = \frac{13,100}{7/8 \times 12 \times 19.5} = 64\ \#/\square''$

$-A_s = \frac{17,500 \times 12}{7/8 \times 18[illegible] \times 19.5} = 0.76\ \square'' - 2\text{-}3/4''\phi @ 0.44 = 0.88\ \square''$

$u = \frac{13,100}{2 \times 2.36 \times 7/8 \times 19.5} = 163\ \#/\square''$

Member AC

$v = \frac{[illegible]}{7/8 \times 12 \times 14.5} = 85\ \#/\square''$

$-A_s = \frac{19,500 \times 12}{7/8 \times 18[illegible] \times 14.5} = 1.03\ \square'' - 1\text{-}3/4''\phi = 0.44$; $1\text{-}7/8''\phi = 0.60$; $1.04\ \square''$

$-A_s = \frac{16,600 \times 12}{7/8 \times 18[illegible] \times 14.5} = 0.87\ \square'' - 2\text{-}3/4''\phi @ 0.44 = 0.88\ \square''$

$+A_s = \frac{10,920 \times 12}{7/8 \times 18[illegible] \times 14.5} = 0.57\ \square'' - 1/8''\phi @ .60 = .6[illegible]\ \square''$

$u_1 = \frac{[illegible]}{[illegible] \times 7/8 \times 14.5} = 198\ \#/\square''$

$u_2 = \frac{[illegible]}{2 \times 2.36 \times 7/8 \times 14.5} = 183\ \#/\square''$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

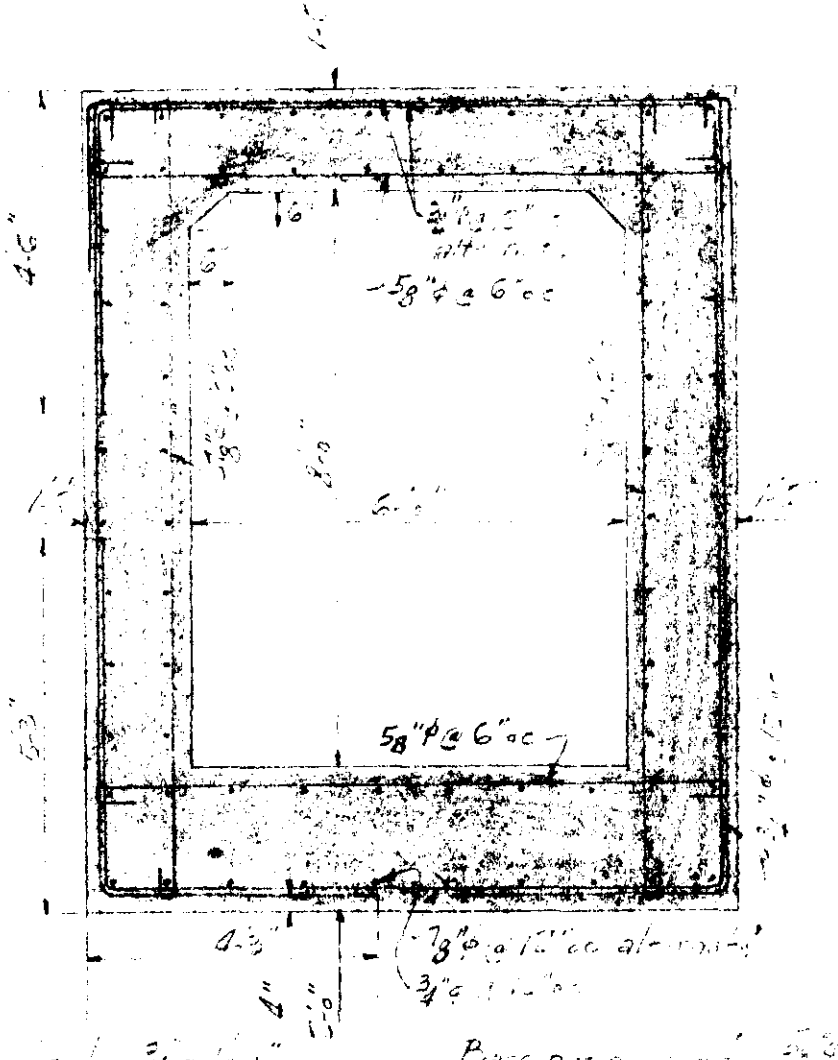
Page

Subject

Computation

Computed by **Checked by** **Date**

U. S. GOVERNMENT PRINTING OFFICE 8-16628



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

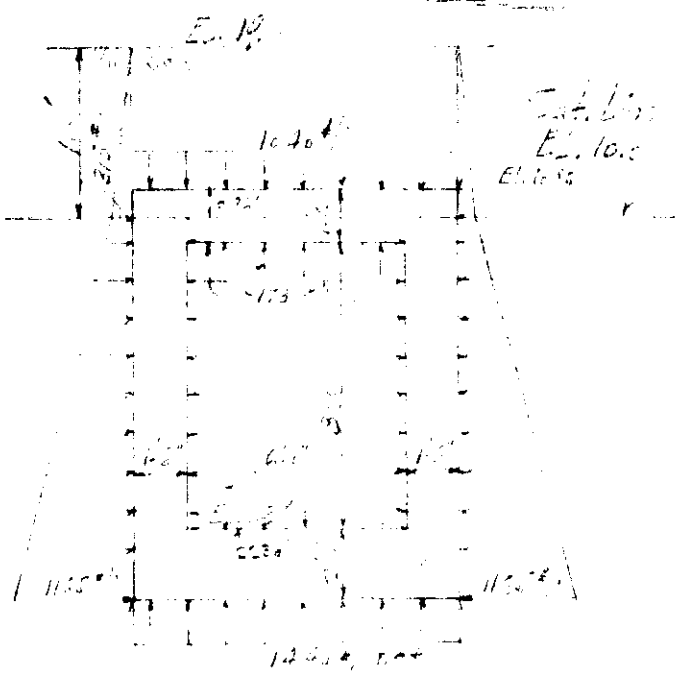
Page 107

Subject: Meadow Hill Pumping Sta. [illegible]

Computation: Dis[illegible] (adjacent to [illegible])

Computed by: [illegible] Checked by: [illegible] Date: 5-[illegible]-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528



8.4 × [illegible]# = 815#
[illegible] = 225
1040#

[illegible] × 62.5 = 1730#
[illegible] × [illegible] = 500
[illegible]

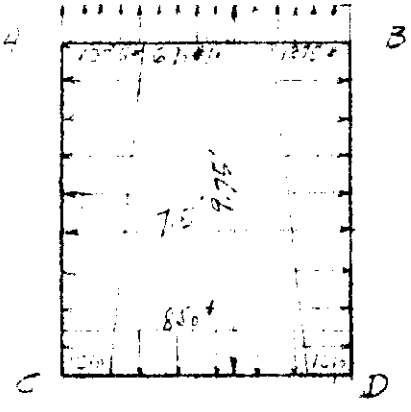
[illegible] × 35 = 315#
10.66 × 80 = 850
1165#

[illegible] = 400#
[illegible]
[illegible]

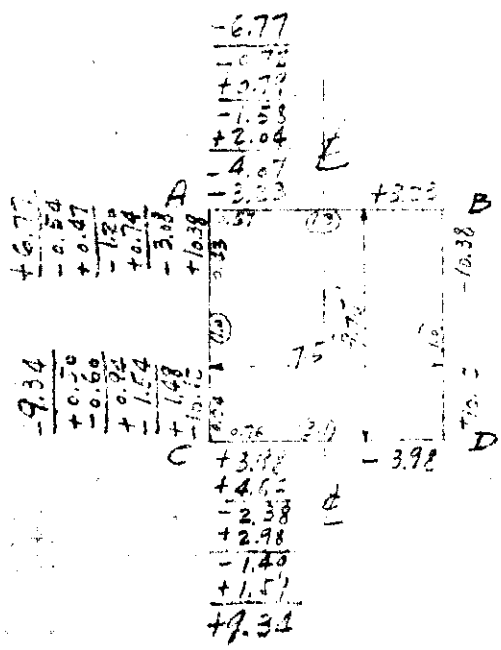
[illegible] = [illegible]
315 − [illegible] = −3[illegible]
[illegible]

[illegible] + [illegible] = [illegible]
1165 [illegible] 1065
1210#

[illegible] = 2293
− 1440
850#



Net Loading



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

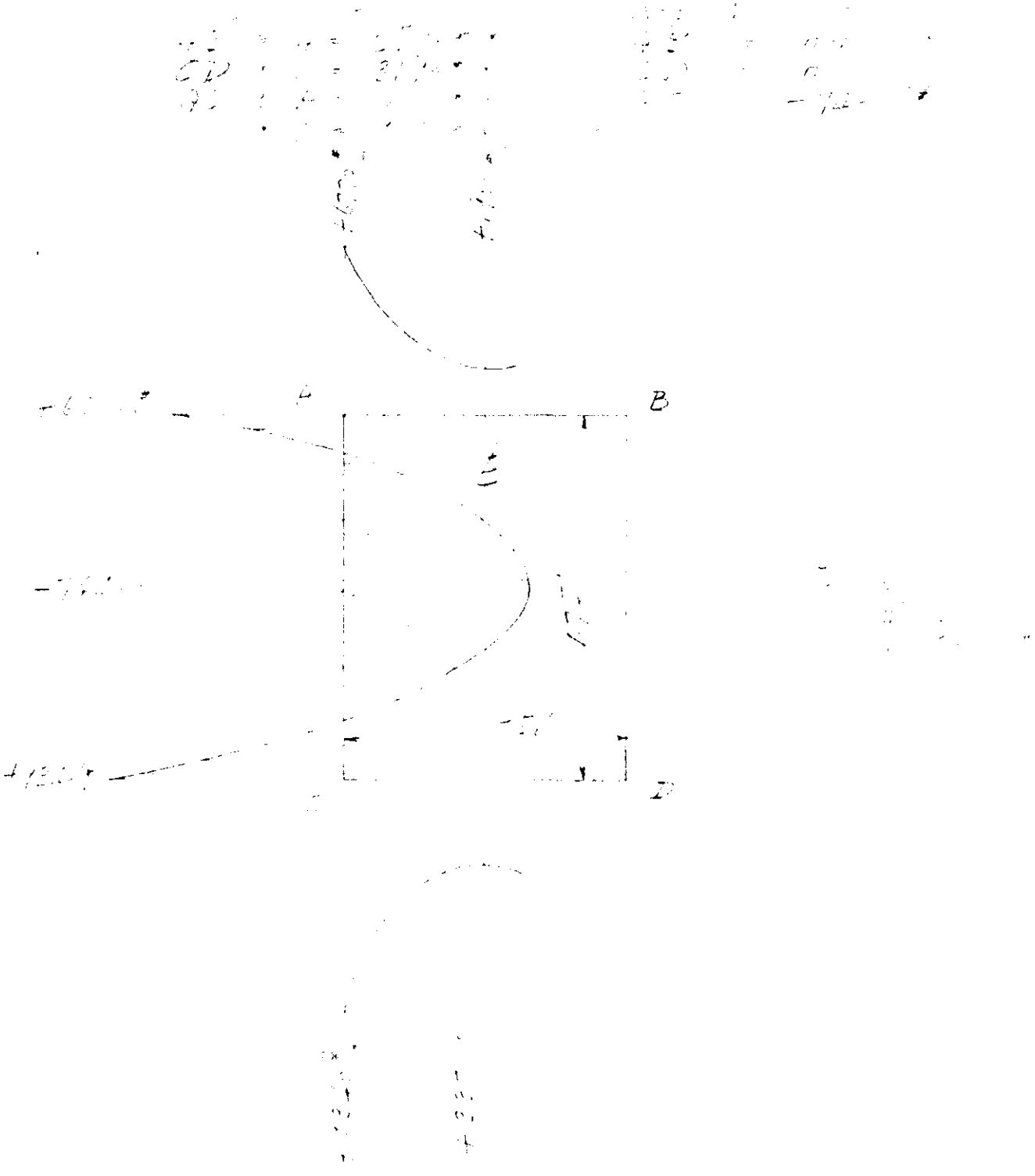
Page

Subject

Computation

Computed by **Checked by** **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10548



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 10[illegible]

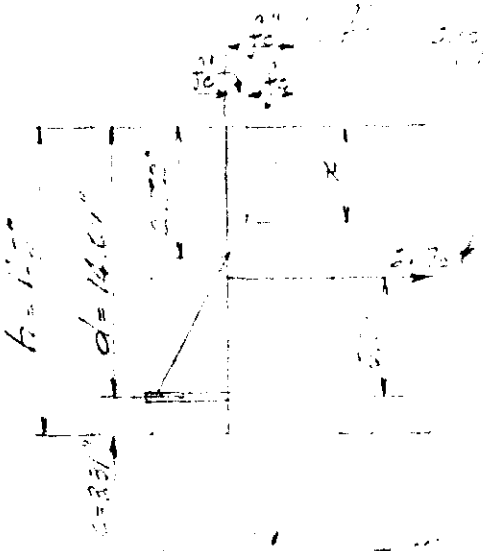
Subject [illegible]

Computation [illegible]

Computed by [illegible] Checked by [illegible] Date [illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10528

[illegible]



$p = \frac{0.31}{12 \times 14.6[illegible]} = 0.00[illegible]$

$k = \sqrt{2 \times 12 \times 0.00[illegible] + (12 \times 0.00[illegible])^2} - 12 \times [illegible]$

$= 0.1853$ ✓

$j = 1.000 - 0.0618 = 0.[illegible]$

$kd = 14.[illegible] \times 0.185 = 2.72$

$f_c'' = \frac{2 \times 6770 \times 12}{0.9[illegible] \times 2.72 \times 14.[illegible] \times 12} = 3[illegible]$ #/□"

[illegible] $f_c' = 98$ #/□" $d = \frac{2[illegible]}{3[illegible]} \times 2.72 = 2.0[illegible]$

$\frac{1}{2} \times 3[illegible] \times 12 \times 2.72 \times 13.[illegible] - \frac{1}{2} \times 270 \times 12 \times 2.02 \times 14.0[illegible] = 6.70 \times 5.[illegible]$ [illegible]

Reduced [illegible] $= \frac{1}{2}(2.72 + 2.0[illegible]) \times 2 \times 98 = [illegible]$ #

[illegible] $f_c = \frac{2170 + 3[illegible]}{0.31} = [illegible]$ #/□"

f_c [illegible] $= \frac{6770 \times 12}{7[illegible] \times 0.31 \times 14.[illegible]} = 2[illegible]$ #/□"

[illegible] $f_c = 3.[illegible]$ #/□"

Using $\frac{5}{8}$"φ × 6" [illegible]

[illegible]

[illegible] $\frac{5}{8}$"φ × 6" [illegible]

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject [illegible]

Computation [illegible]

Computed by [illegible] Checked by [illegible] Date 5-[illegible]-41

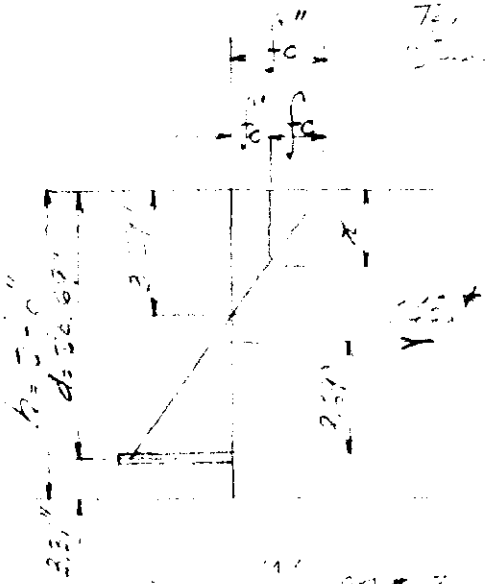
U. S. GOVERNMENT PRINTING OFFICE 3—10528

Member [illegible]

[illegible] = [illegible] #

[illegible] = [illegible] #

[illegible] = 0.31 □"



$$p = \frac{0.31}{12 \times 20.69} = 0.00125$$

$$k = \sqrt{2 \times 12 \times 0.00125 + (12 \times 0.00125)^2} - 12 \times 0.00125$$

$$= \underline{0.159} \qquad j = 1.0 - 0.053 = \underline{0.947}$$

$$kd = 0.159 \times 20.69 = 3.29"$$

$$f_c'' = \frac{2 \times 934 \times 12}{0.947 \times 3.29 \times 20.69 \times 2} = 290 \text{ \#/□"}$$

Then $f_c'' = 87$ #/□" $\quad x = \frac{203}{290} \times 3.29 = 2.31"$

$$\tfrac{1}{2} \times 290 \times 2 \times 3.29 \times 11.57 - \tfrac{1}{2} \times 203 \times 12 \times 2.31 \times 19.90 = 6430 \times 8.69 \text{ (bearing)}$$

Reinforced Concrete Concrete $= \tfrac{1}{2}(3.29 + 2.31) \times 87 = 2920$ #

[illegible] $\frac{6430 - 2920}{0.31} = [illegible]$ #/□"

$$f_s \text{ (bearing)} = \frac{934 \times 12}{7/8 \cdot 0.31 \times 20.69} = 20[illegible] \text{ \#/□"}$$

[illegible] 5/8" @ 6" [illegible] f_s (bearing) = [illegible] #/□"

[illegible] = [illegible] #/□"

[illegible] 5/8" @ [illegible]

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject Meadow Hill Pumping Sta. [illegible]

Computation Discharge Conduit

Computed by W. W. Z. **Checked by** [illegible] **Date** 5-22-41

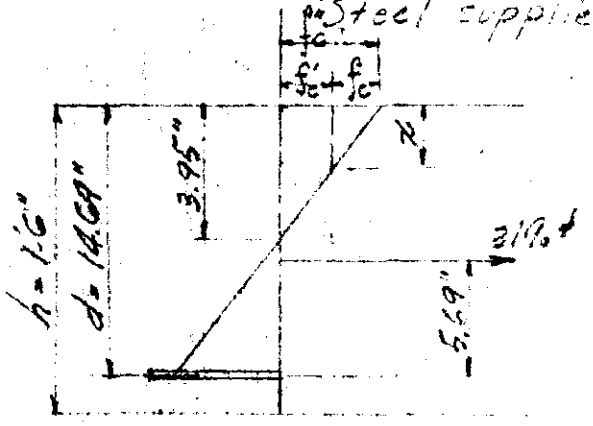
U. S. GOVERNMENT PRINTING OFFICE 3—10528

Member AC

M_1 = Moment at support = 9340 #

Tension on section = 3190 #

Steel supplied = 7/8" ⌀ @ 12" o.c. = 0.60 □"



$$p = \frac{0.60}{12 \times 14.69} = 0.00341$$

$$k = \sqrt{2 \times 12 \times 0.00341 + (12 \times 0.00341)^2} - 12 \times 0.00341$$

$$= 0.248$$

$$j = 1.000 - 0.08 = 0.92$$

$$kd = 0.248 \times 14.69 = 3.64''$$

$$f_c'' = \frac{2 \times 9340 \times 12}{0.92 \times 3.64 \times 14.69 \times 12} = 380 \text{ \#/□"}$$

When $f_c' = 40$ #/□" $x = \frac{340}{380} \times 3.64 = 3.26''$

$\frac{1}{2} \times 380 \times 12 \times 3.64 \times 13.48 - \frac{1}{2} \times 340 \times 12 \times 3.26 \times 13.61 = 3190 \times 5.69$ (nearly)

Reduced Stress on Concrete $= \frac{1}{2}(3.64 + 3.26) \times 40 \times 12 = 1660$ #

Increase in $f_s = \frac{3190 - 1660}{0.60} = 2550$ #/□"

f_s (for bending) $= \frac{9340 \times 12}{7/8 \times 0.60 \times 14.69} = 14{,}550$ #/□"

Actual $f_s = 17{,}100$ #/□"

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject: Meadow Hill Pumping Sta. EH 6c

Computation: Discharge Conduit

Computed by: W. W. Z. Checked by: [illegible] Date: 5-[illegible]-[illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Member AC

Moment at Center = 7440 '#

Tension at Section = 2590 # d = 14.62"

Steel Supplied = 3/4"φ @ 12" o.c. = 0.44 □"

$$p = \frac{0.44}{12 \times 14.62} = 0.0025$$

$$k = \sqrt{2 \times 12 \times 0.0025 + (12 \times 0.0025)^2} - 12 \times 0.0025$$

$$= 0.217$$

$$kd = 0.217 \times 14.62 = 3.18" \qquad j = 1.000 - 0.072 = 0.928$$

$$f_c'' = \frac{2 \times 7440 \times 12}{0.928 \times 3.18 \times 14.62 \times 12} = 345 \#/\square"$$

When $f_c' = 30 \#/\square"$ $x = 2.90"$

$$\tfrac{1}{2} \times 345 \times 12 \times 3.18 \times 13.51 - \tfrac{1}{2} \times 315 \times 12 \times 2.90 \times 13.45 = 2590 \times 5.62 \text{ [illegible]}$$

Reduced stress on Concrete = $\frac{1}{2}(2.90 + 3.18) 12 \times 30 = 1090$ #

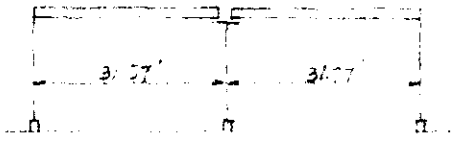
Increase in f_s = $\frac{2590 - 1090}{0.44} = 3400$ #/□"

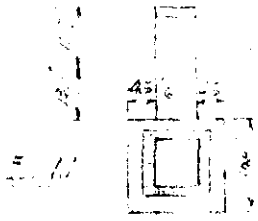
$$f_s \text{ (bending)} = \frac{7440 \times 12}{7/8 \times 0.44 \times 14.62} = 15800 \#/\square"$$

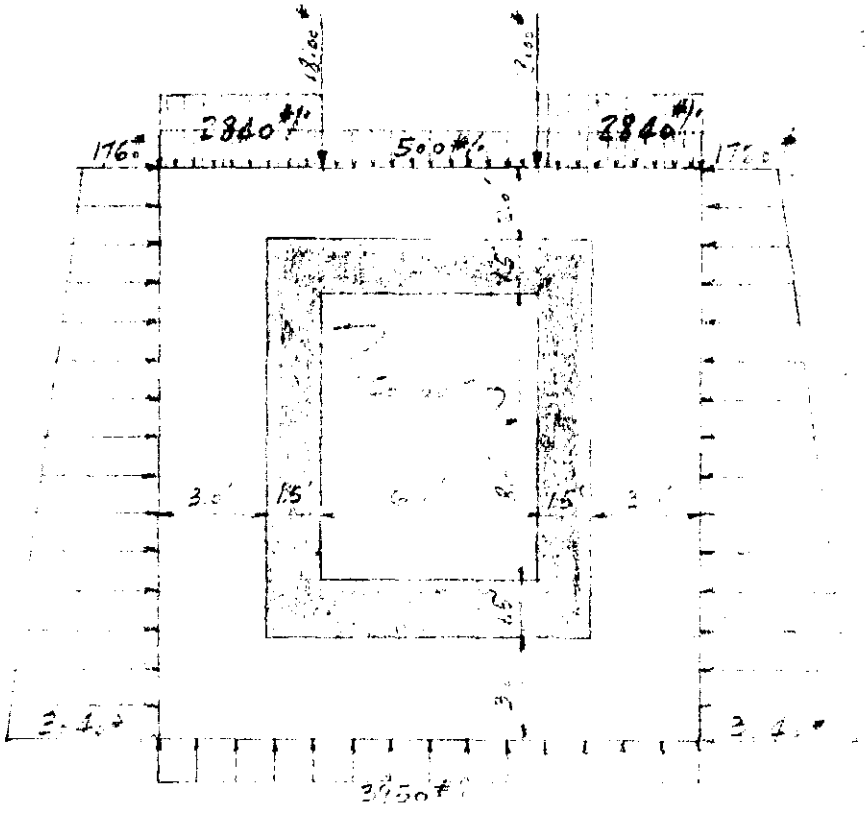
Actual f_s = 19200 #/□" OK

Subject
Computation
Computed by Checked by Date

U. S. GOVERNMENT PRINTING OFFICE 3—10528



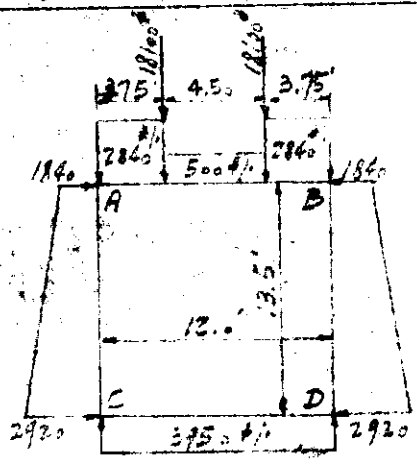


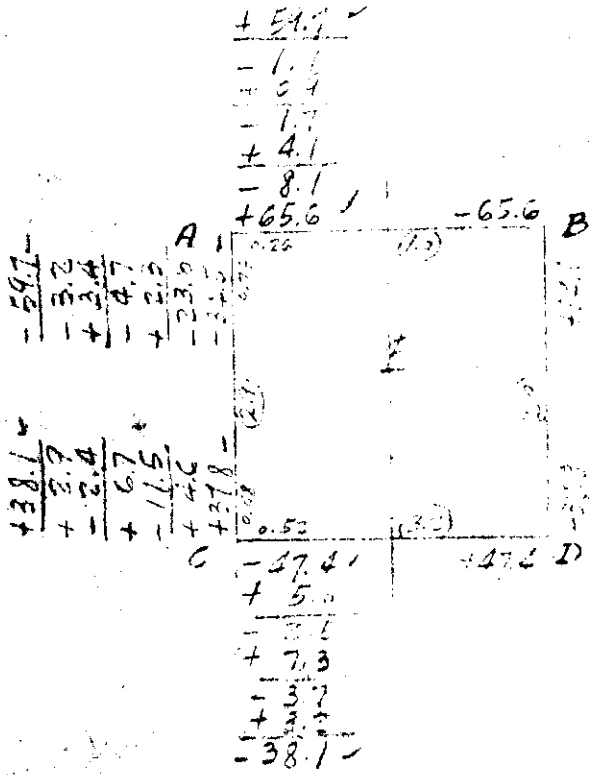


WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.
Page 114

Subject Meadow Hill Pumping Sta.
Computation Seep Ring under Foot Bridge
Computed by W. W. Z. Checked by [illegible] Date 5-17-41

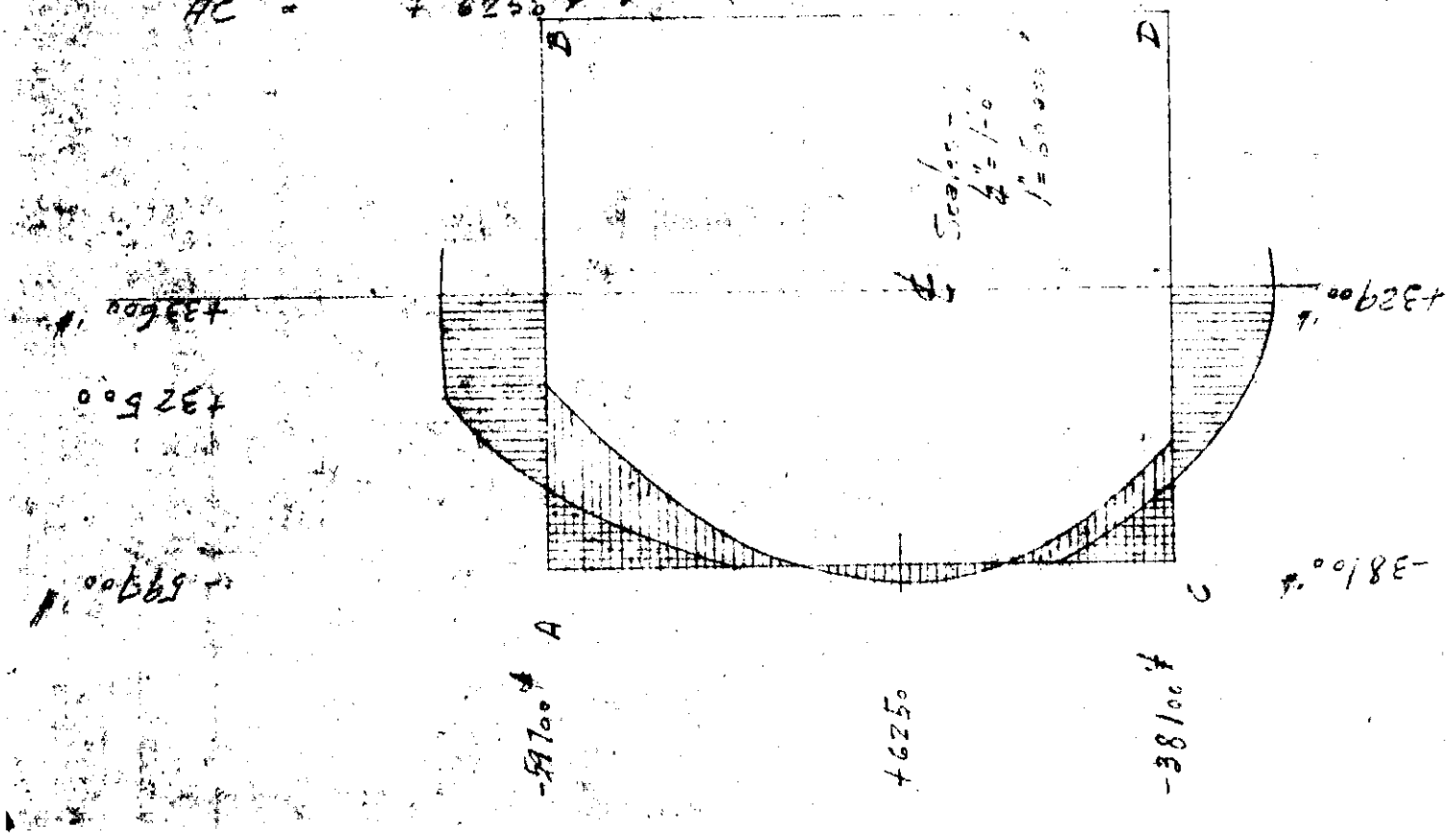
U. S. GOVERNMENT PRINTING OFFICE 3—10528





Shears —
AB @ A = 29875# ✓
CD @ C = 23700# ✓
AC @ A = 16430# ✓
@ C = 15660# ✓

Positive Moments —
AB = +33600'# ✓
CD = +32900'# ✓
AC = +6250'# ✓



Subject
Computation
Computed by Checked by Date

U. S. GOVERNMENT PRINTING OFFICE 3—10528

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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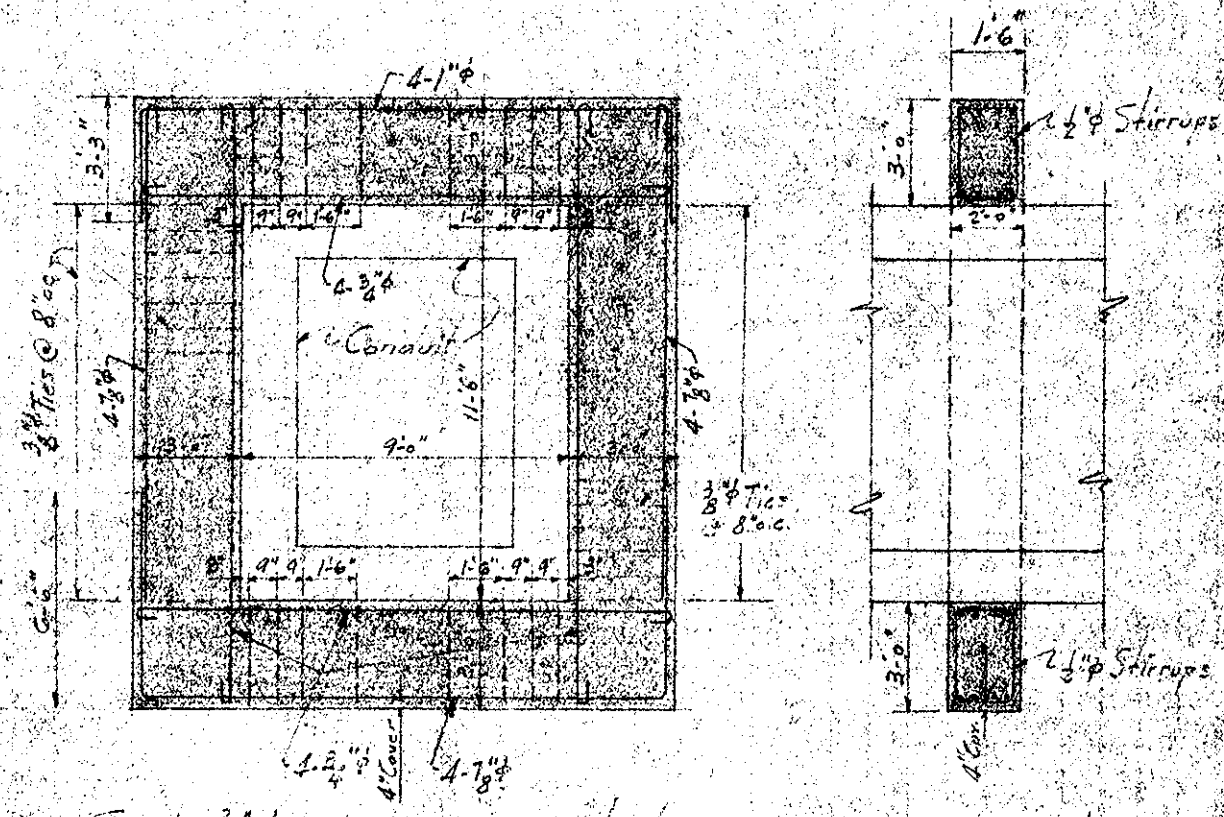
Subject Meadow Hill Pumping Sta. EH Co

Computation Seep Ring

Computed by W. M. Z. **Checked by** [illegible] **Date** 5-19-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Scale 3/8" = 1'-0"

Steel Cover 3" except where shown

Two Seep Rings as shown above required
One under each Service Bridge Pier

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

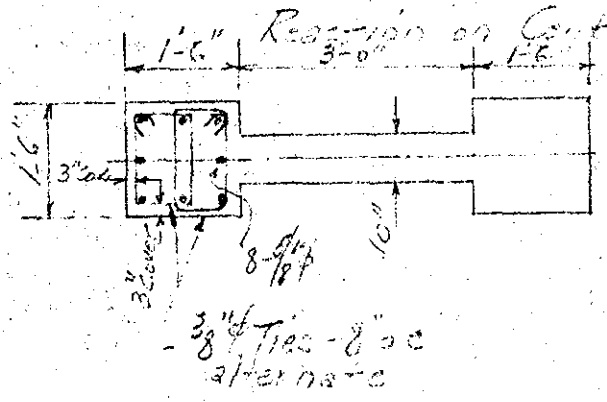
Subject Meadow Hill Pumping Sta. [illegible]

Computation Service Bridge Piers

Computed by W. W. Z. **Checked by** ..... **Date** 5-23-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528

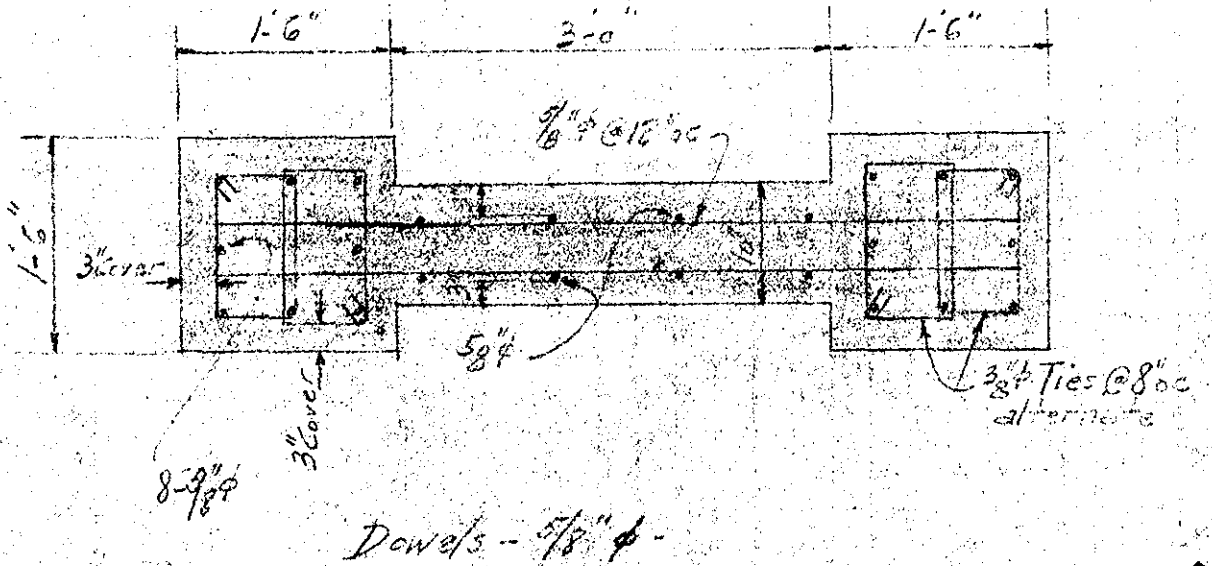
Reaction on Center Pier = 10300#



$$\frac{\frac{1}{2} \times 10300}{18 \times 18} = 160 \text{ \#/□"}$$

Use 1% × (18 × 18) = 3.24□"

Use 8-5/8"φ bars



Dowels - 5/8"φ -

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Sta. EL 66

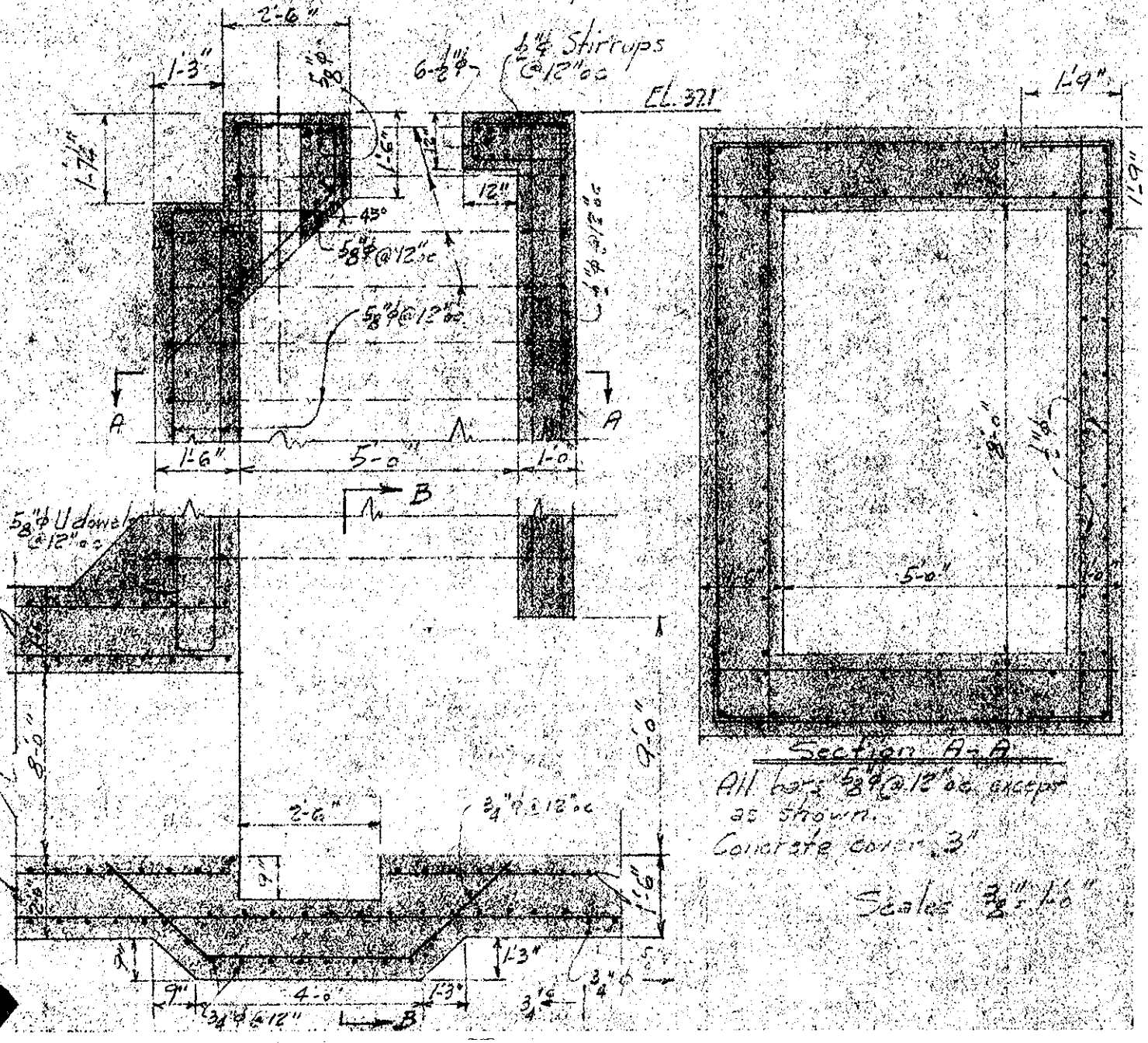
Computation Discharge Outlet Gate Structure

Computed by H. R. Z. **Checked by** W.E.J. **Date** 5-20-41

U. S. GOVERNMENT PRINTING OFFICE 3—10529

With the river up to EL 371 the Gate Structure is subjected to an equal pressure on the inside and outside consequently minimum steel reinforcement will suffice.

The total end reaction of the service bridge and the total weight of the gate structure will be taken by the side walls of the discharge conduit and distributed over the area of the base slab from the expansion joint to the end of the outlet portal.



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Meadow Hill Pumping Sta. EHSc

Computation: Discharge Outlet Gate Structure & Portal

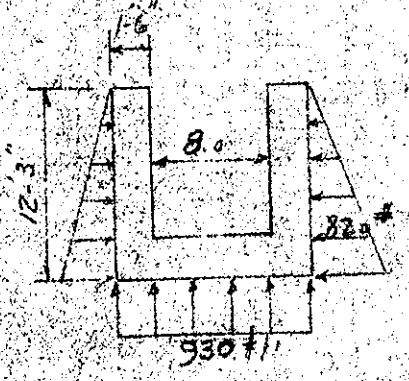
Computed by: W. W. Z. Checked by: [illegible] Date: 5-20-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Reaction of Bridge on Gate Structure = 5200 # ✓
Wgt. Floor Stand = 2000 ✓
Wgt. of Gate & Frame = 9500 ✓
Wgt. of Gate Structure = 173000 ✓
Wgt. of Ladder = 300
190000 # ✓

Increase in Soil Pressure due to above =

$$\frac{190000}{(21.8\times11)+(14.7\times9)} = 510\ \#/\square'$$



$$\frac{2\times10.25\times225}{11} = \frac{4620}{11} = 420\ \#/'$$ ✓

510
930 #/'

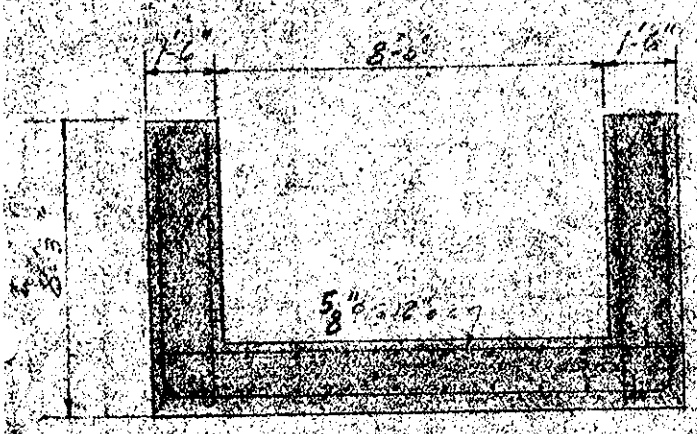
$10.25\times80 = 820\ \#$ ✓

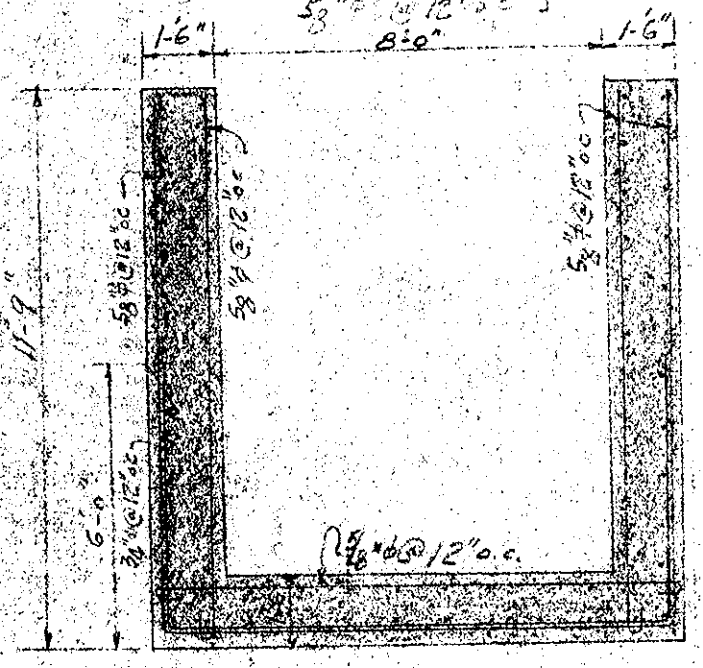
Moment in walls $= \frac{1}{2}\times820\times\frac{10.25^2}{3} = 14400$ '# ✓

$d = 18-3\frac{1}{2} = 14.5''$ $A_s = \frac{14400\times12}{7/8\times18000\times14.5} = 0.76\ \square''$ ✓

Use $\frac{3}{4}$"ϕ @ 12" o.c. } alternate
$\frac{5}{8}$"ϕ @ 12" o.c. }

Base Slab –
Moment at center:
$M = 14,400 - 930\times\frac{7.5}{8} = 13,900$ '#
(no reversal of moment)





All other bars $\frac{5}{8}$"ϕ @ 12" o.c.

All other bars $\frac{5}{8}$"ϕ @ 12" o.c.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject: Meadow Hill Pumping Sta. EH 6c

Computation: Discharge Gate Structure

Computed by: W. W. Z. Checked by: [illegible] Date: 4-26-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Sides of Gate Structure (=Sides of Conduit)

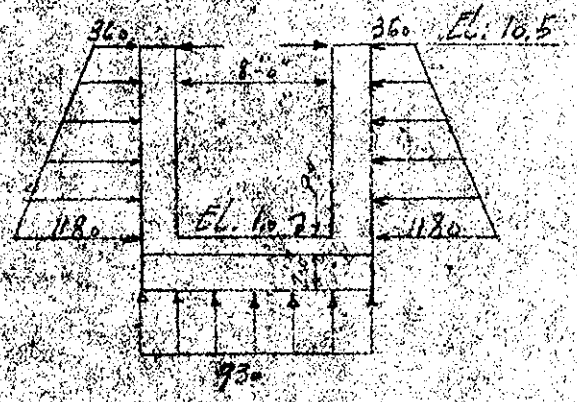
Conduit empty - saturated earth

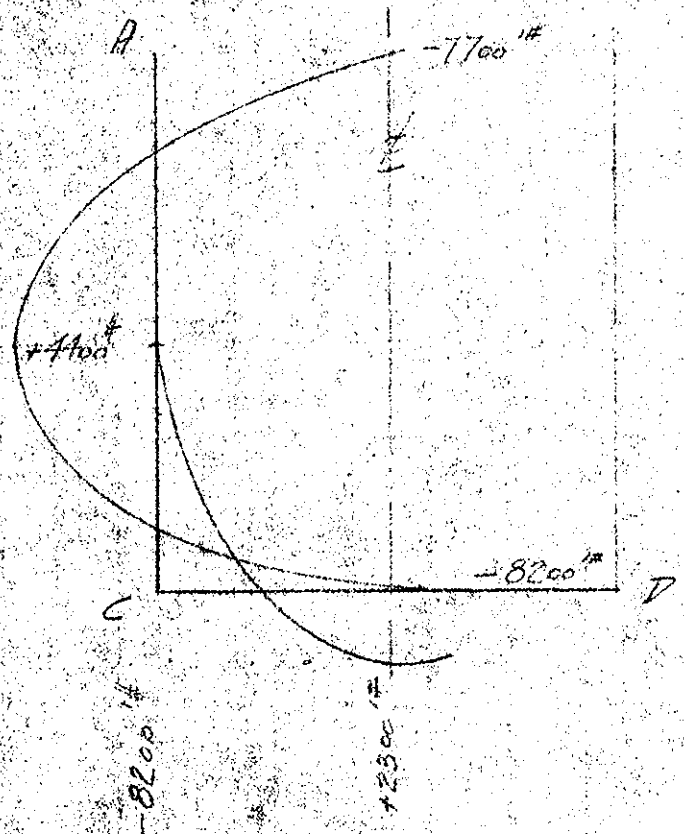
$4.5 \times 80 = 360$ #

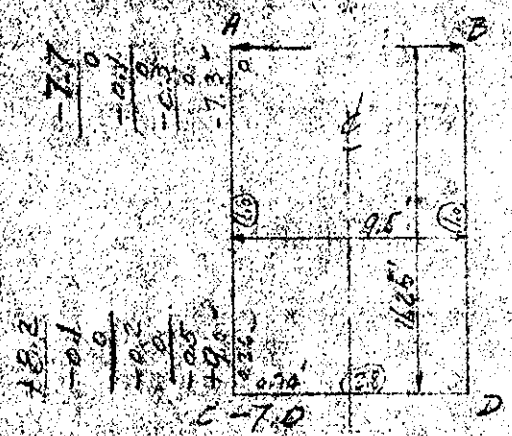
$10.3' \times 80 = 820$

1180 #/'

Net base soil pressure = 930 #/'







C -7.0
-1.5
+0.8
-0.6
+0.3
-0.2
-8.2

Shears

CD @ C = 4410 #

AC @ A = 3530 #

@ C = 5150 #

Max Pos. Moment

CD = +2,800 #

AC = +4,400

Member AC $-A_s = \frac{8200 \times 12}{7/8 \times 18000 \times 14.5} = 0.43$ □"

$+A_s = \frac{44}{82} \times 0.43 = 0.23$ □"

$v = \frac{5150}{7/8 \times 12 \times 14.5} = 34$ #/□"

Member CD $-A_s = \frac{8200 \times 12}{7/8 \times 18000 \times 19.5} = 0.32$ □"

$+A_s = \frac{23}{82} \times 0.32 = 0.09$ □"

$v = \frac{4410}{7/8 \times 12 \times 19.5} = 22$ #/□"

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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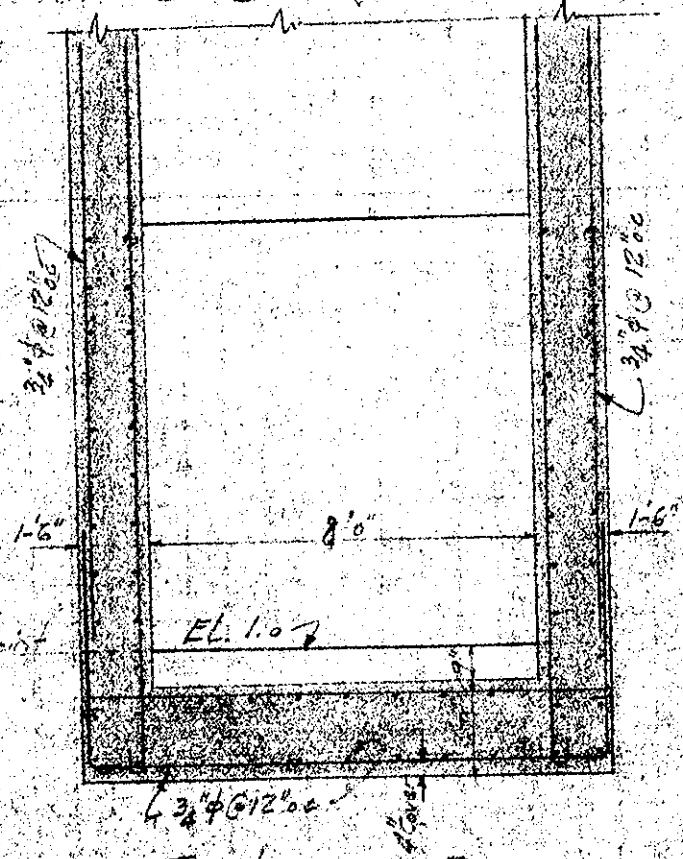
Subject: Meadow Hill Pumping Sta. E4 6c

Computation: Discharge Gate Structure

Computed by: W. W. Z. Checked by: [illegible] Date: 5-26-41

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Section B-B (see Sheet 21)



Section B-B
Scale 1/4" = 1'-0"

All bars not marked = 5/8"φ @ 12" o.c.
Concrete cover 3" except as shown.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Meadow Hill Pumping Station

Computation Discharge Outlet Gate Structure

Computed by [illegible] **Checked by** ..... **Date** June 12, 1941.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

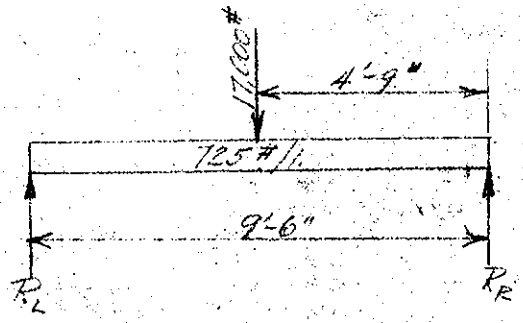
Investigation of slab under floor stand

Weight of floor stand 2,000#

Load due to opening gate 15,000

Total = 17,000#

Case I. Assume slab & gate as restained beam at right angles to ℄ conduit.



Dead load = 2.5 x 1.6 x 150 = 600#/l.

Live load = 2.5 x 50 #/□' = 125#/l.

725 #/l.

$R_L = R_R = 725 \times 4.75 + \frac{17,000}{2} = 3440 + 8500 = 11,940$ #

$-M = \frac{1}{8} \times 17000 \times 9.5 + \frac{1}{12} \times 725 \times \overline{9.5}^2 = 25,700$ '#

$+M = \frac{1}{8} \times 17,000 \times 9.5 + \frac{1}{24} \times 725 \times \overline{9.5}^2 = 22,900$ '#

"d" required = $\sqrt{\frac{22,900 \times 12}{123 \times 30}}$ = 8.65" - "d" supplied = 16"

$-A_s = \frac{25,700 \times 12}{7/8 \times 16.0 \times 18,000} = 1.23$ □" - 4 - 7/8"ϕ @ .31 = 1.24 □"

$+A_s = \frac{22,900 \times 12}{7/8 \times 16.0 \times 18000} = 1.09$ □" - 4 - 7/8"ϕ @ .31 = 1.24 □"

Unit shear = $\frac{11,940}{7/8 \times 16 \times 30}$ = 28 #/□" o.k.

Unit bond = $\frac{11,940}{7.86 \times 7/8 \times 16}$ = 109 #/□" - Special anchorage

WAR DEPARTMENT

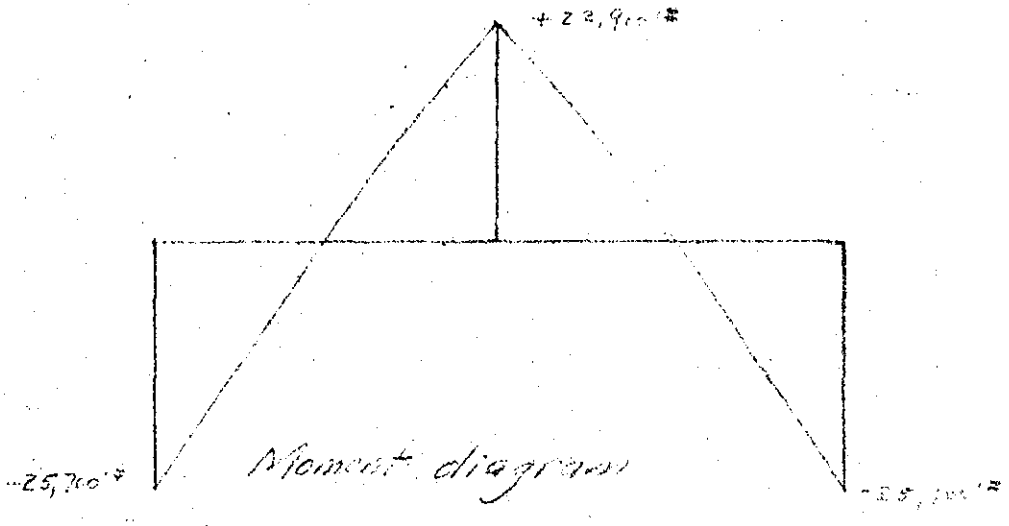
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

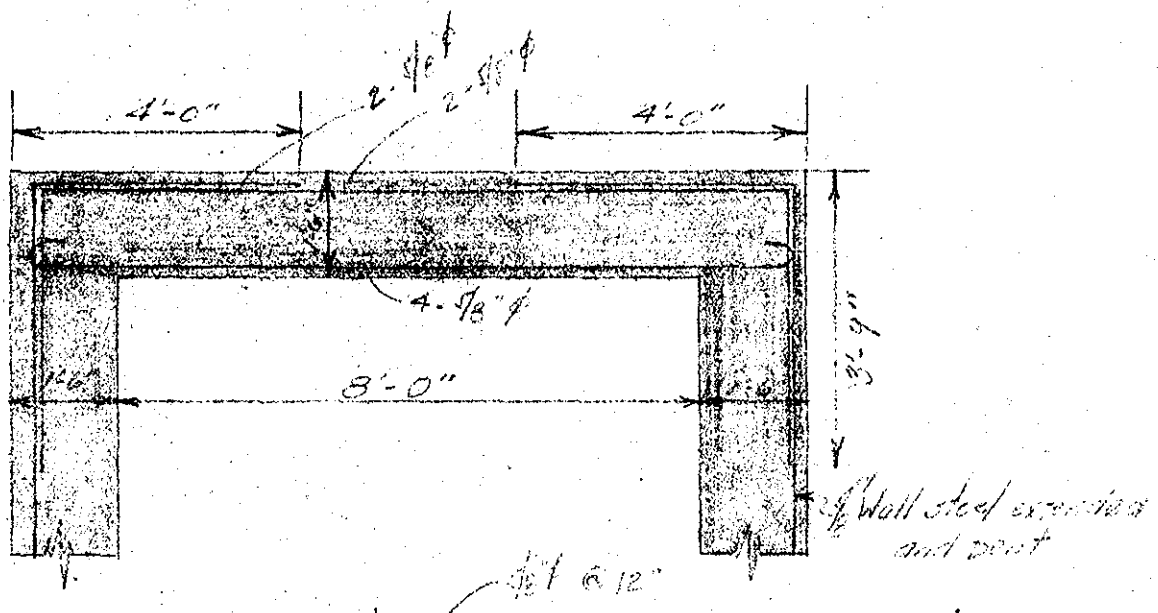
Subject: Meadow Hill Pumping Station

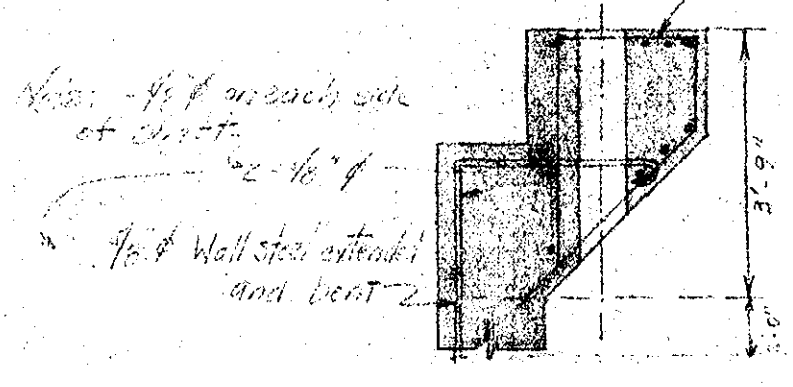
Computation: Discharge Outlet Gate Structure

Computed by: [illegible] Checked by: Date: June 12, 1941

U. S. GOVERNMENT PRINTING OFFICE 3—10528







Subject: Meadow Hill Pumping Station
Computation: Discharge Outlet Gate Structure
Computed by: W.R.J. Jr. Checked by: Date: June 12, 1944

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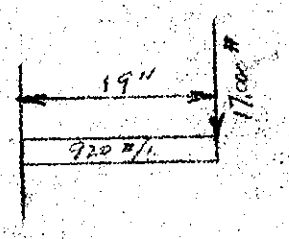
Case II. Assume beam to act as cantilever, along axis of conduit.



Dead load = 3.75 × 1.5 × 150 = 845 #/l.
Live load = 1.5 × 50 = 75
920 #/l.

R = 920 × 1.58 + 17,000 = 18,500 #
M = 17,000 × 1.58 + 920 × 1.58²/2 = 28,000 '#

Required "d" = $\sqrt{\frac{28000 \times 12}{14.7 \times 18}}$ = 11.3" - "d" supplied = 23"

$A_s = \frac{28000 \times 12}{7/8 \times 23 \times 18000}$ = 0.93 □" - 3-7/8" ⌀ @ .31 = 0.93 □"

Unit shear = $\frac{18,500}{7/8 \times 23 \times 18}$ = 57 #/□"

Unit bond = $\frac{18,500}{5.89 \times 7/8 \times 23}$ = 156 #/□" Special anchorage

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Meadow Hill Pumping Sta.
Computation: Concrete Roof Slab
Computed by: W. W. Z. Checked by: [illegible] Date: 4-30-41.

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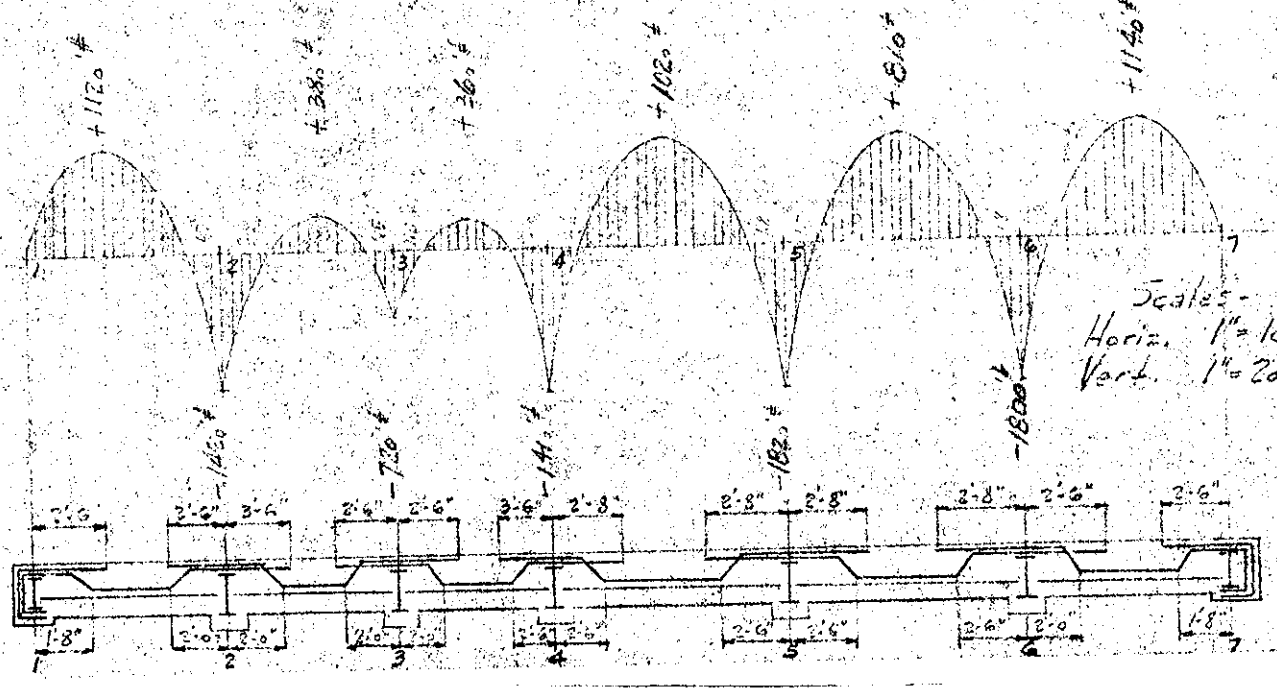
Roof Loads
L.L. = 40 #/□'
Roofd = 5
Conc. Fill = 30
5" Slab = 63
140 #/□'

Required $d = \sqrt{\frac{1820}{147}} = 3.5''$

Use 5½" Concrete Slab
½" □ bars @ 8" o.c.
alternate bars bent

140 #/□'

	① 10'-0"	② 9'-2"	③ 9'-0"	④ 12'-3"	⑤ 12'-3"	⑥ 10'-6"	⑦
	1.00	0.47 0.53	0.50 0.50	0.58 0.42	0.50 0.50	0.46 0.54	1.00
	+1.17	-1.17 +0.95	-0.95 +0.95	-0.95 +1.75	-1.75 +1.75	-1.75 +1.29	-1.29
	-1.17	+0.10 +0.12	0 0	-0.46 -0.34	0 0	+0.21 +0.25	+1.29
	+0.05	-0.59 0	+0.06 -0.23	0 0	-0.17 +0.11	0 +0.65	-0.13
	-0.05	+0.28 +0.31	+0.09 +0.08	0 0	+0.03 +0.03	-0.30 -0.35	+0.13
	+0.14	-0.03 +0.05	+0.16 0	+0.04 +0.02	0 -0.15	+0.02 -0.07	-0.18
	-0.14	-0.01 -0.01	-0.08 -0.08	-0.04 -0.02	+0.07 +0.08	+0.02 +0.03	+0.18
$-M^{ik}$	0	-1.42 +1.42	-0.72 +0.72	-1.41 +1.41	-1.82 +1.82	-1.80 +1.80	0
V^k	0.56	0.84 0.71	0.55 0.55	0.71 0.82	0.90 0.86	0.86 0.90	0.57
R^k	0.56	1.55	1.10	1.53	1.76	1.76	0.57
$+M^k$	4.0' +1.12	5.1' +0.38	3.9' +0.36	5.9' +1.02	6.1' +0.81	4.0' +1.14	
A_s □"	0.23	0.29 0.08	0.15 0.07	0.29 0.21	0.37 0.16	0.37 0.23	



WAR DEPARTMENT

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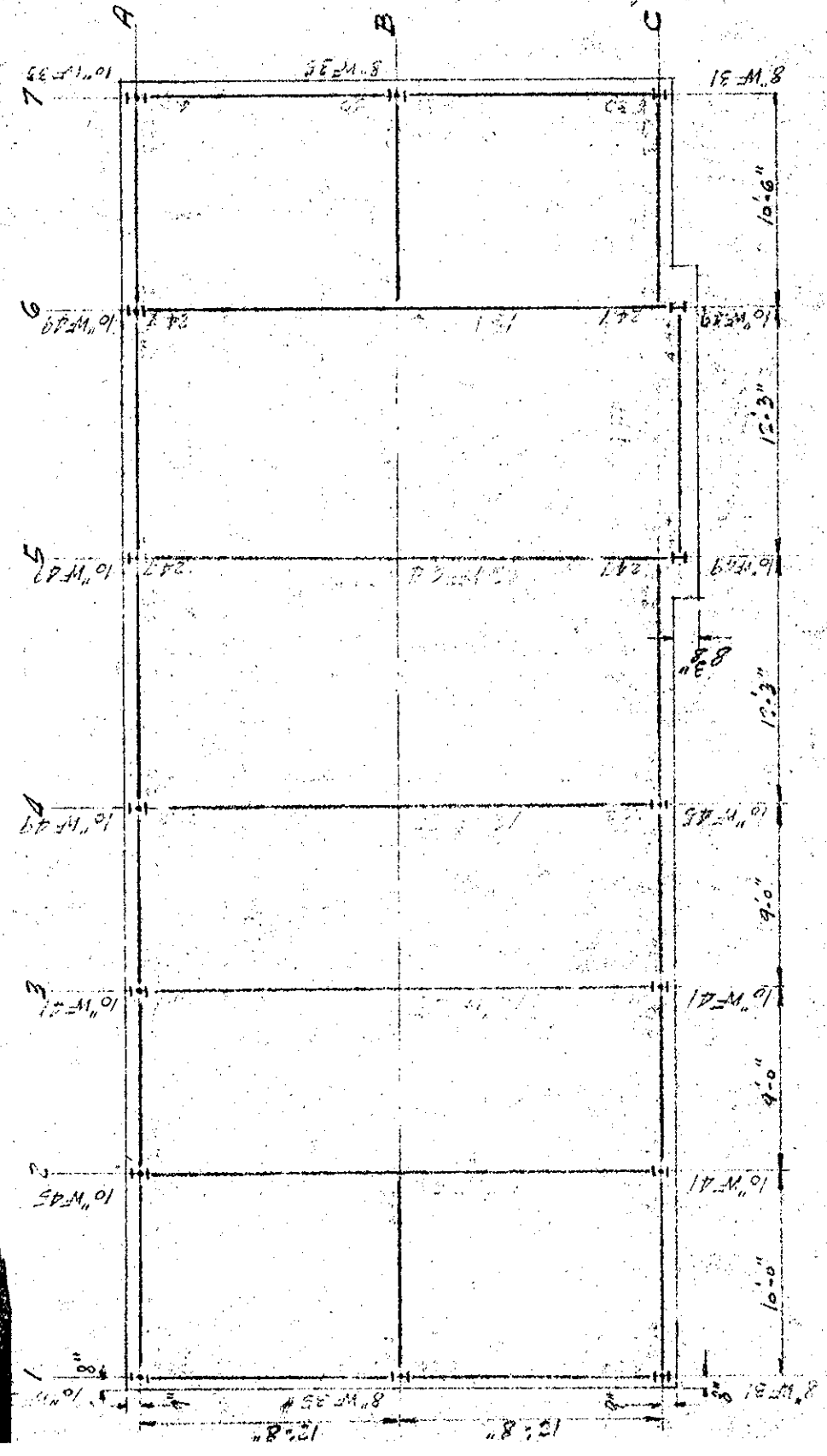
Subject Meadow Hill Pumping Sta.

Computation

Computed by W. H. Z. Checked by [illegible] Date 4-30-41

U.S. GOVERNMENT PRINTING OFFICE 2—10628



Roof Framing

Beam sizes not shown are 8"x17#

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject: Meadow Hill Pumping Sta. EH 6c

Computation: Steel Roof Beams

Computed by: W. W. Z. Checked by: [illegible] Date: 4-30-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Bm. 2-2

Load from Roof = 1550 #/' ✓
16" Bm. & Frpfg. = 240
1800 #/' ✓

1800 #/'
R_L 24.67' R_R

$R_L = R_R = 1800 \times 24.67 \times \frac{1}{2} = 22200$ # ✓

$M = \frac{1}{8} \times 1800 \times \overline{24.67}^2 = 137000$ '# ✓

$S = \frac{137.0}{1.5} = 91.3$ ins^3 ✓

Use 16" WF 58# ✓

Bm. 3-3

Load from Roof = 1100 #/' ✓
16" Bm. & Frpfg. = 240
1350 #/' ✓

1350 #/'
R_L 24.67' R_R

$R_L = R_R = 1350 \times 24.67 \times \frac{1}{2} = 16700$ # ✓

$M = \frac{1}{8} \times 1350 \times \overline{24.67}^2 = 103000$ '# ✓

$S = \frac{103.0}{1.5} = 68.6$ ins.^{3} ✓

Use 16" WF 45# ✓

Bm. 4-4

Load from Roof = 1530 #/'
16" Bm. & Frpfg. = 240
1800 #/'

1800 #/'
R_L 24.67' R_R

$R_L = R_R = 1800 \times 24.67 \times \frac{1}{2} = 22200$ #

$M = \frac{1}{8} \times 1800 \times \overline{24.67}^2 = 137000$ '#

$S = \frac{137.0}{1.5} = 91.5$ ins^3

Use 16" WF 58# ✓

Bm. 5-5

Load from Roof = 1760 #/'
16" Bm. & Frpfg. = 240
2000 #/'

2000 #/'
R_L 24.67' R_R

$R_L = R_R = 2000 \times 24.67 \times \frac{1}{2} = 24700$ #

$M = \frac{1}{8} \times 2000 \times \overline{24.67}^2 = 152000$ '#

$S = \frac{152.0}{1.5} = 101.5$ ins^3

Use 16" WF 64# ✓

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject Meadow Hill Pumping Sta. EH 6c

Computation Steel Roof Beams

Computed by W. W. Z. Checked by [illegible] Date 4-30-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Bm. 6-6

Load from Roof = 1760 #/'
16" Bm & Frp fg. 240
2000 #/'

2000 #/'
R_L 24.67' R_R

$R_L = R_R = 2000 \times 24.67 \times \frac{1}{2} = 24700$ #

$M = \frac{1}{8} \times 2000 \times \overline{24.67}^2 = 152000$ '#

$S = \frac{152.0}{1.5} = 101.5$ ins³

Use 16" WF 64# ✓

Bm 5A-6A (Typical)

3'-0" Parapet 150# stone
2'-0" @ 120 240 brick
390 #/'
8" Bm. & Frp fg. = 90
480 #/'

$R_L = R_R = 480 \times 12.25 \times \frac{1}{2} = 2940$ # ✓

$M = \frac{1}{8} \times 480 \times \overline{12.25}^2 = 9000$ '# ✓

$S = \frac{9.00}{1.5} = 6.0$ ins³ ✓

Use 8" WF 17# ✓

Bm 1A-1B (Typical)

Load from Roof = 560 #/'
Parapet = 390
8" Bm & Frp fg. = 90
1040 #/'

$R_L = R_R = 1040 \times 6.0 = 6240$ #

$M = \frac{1}{8} \times 1040 \times \overline{12}^2 = 18700$ '# $S = \frac{18.7}{1.5} = 12.5$ ins³ ✓

Use 8" WF 17# ✓

Bm 7A-7B (Typical)

Load = 1050 #
$R_L = R_R = 6300$ #
$M = 18900$ '# $S = \frac{18.9}{1.5} = 12.6$ ins³

Use 8" WF 17# ✓

Bm 5c-6c

5'-0" Parapet 150
4'-0" @ 120 = 480
8" Bm. Frp fg. = 90
720 #/'

$R_L = R_R = 725 \times 12.25 \times \frac{1}{2} = 4450$ # ✓

$M = \frac{1}{8} \times 725 \times \overline{12.25}^2 = 13600$ '# ✓

$S = \frac{13.6}{1.5} = 9.1$ ins³

Use 8" WF 17# ✓

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject: Meadow Hill Pumping Sta. EH 6c

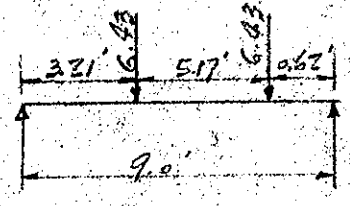
Computation: Crane Beams

Computed by: W. W. Z. Checked by: [illegible] Date: 4-30-41

U. S. GOVERNMENT PRINTING OFFICE 3—10623

Crane: 5 ton crane
Max. Wheel Load = 6430 #
C. to C. wheels = 5'-2"
30 # rail

Bm. A2-A3



L.L. Moment = $12860 \times \frac{3.21^2}{9.00}$ = 14700 '# ✓

25% Impact = 3680 ✓

D.L. Moment $\frac{1}{8} \times 50 \times 9.0^2$ = 510

18900 '# ✓

Horiz. Thrust = 20% Crane Capacity = $\frac{1}{5} \times 10000 \times \frac{1}{4}$ = 500 #/wheel ✓

Lat. L.L. Moment = $\frac{500}{6430} \times 18380$ = 1430 '# ✓

Try 10" WF 26# Flange 5¾" S_{xx} = 27.6 S_{yy} = 5.0

Allow. $f_s = \frac{20000}{1 + \frac{(108)^2}{2000(5.75)^2}}$ = 17000 #/□"

Unit Stress due to Vert. Loads $\frac{1890 \times 12}{27.6}$ = 8,200

Horiz. Loads $\frac{1430 \times 12}{2 \times 5.0}$ = 6,900

15,100 #/□"

Use 10" WF 26# ✓

Max. Shear due to Horiz. Thrust

$500 \times \frac{3.23}{9.0} + 500$ = 712 ✓

25% Impact = 178 ✓

890 # ✓

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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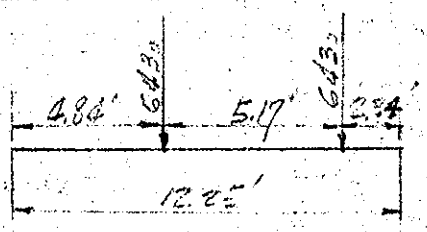
Subject: Meadow Hill Pumping Sta EH6c

Computation: Crane Beams

Computed by: W. W. Z. Checked by: [illegible] Date: 5-1-40

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Bm A5-A6



L.L. Moment $= 12860 \times \frac{\overline{4.84}^2}{12.25} = 24600$ '#

25% Impact $= 6150$

D.L. Mom. $\frac{1}{8} \times 50 \times \overline{12.25}^2 = 950$

31700 '#

Horiz. Thrust per Wheel = 500 #

Lateral L.L. Mom $= \frac{500}{6430} \times 30750 = 2390$ '#

Try 10" WF 33# Flange 8" $S_{xx} = 35.0$ $S_{yy} = 9.2$

Allow. $f_s = \frac{20000}{1 + \frac{(147)^2}{2000(8)^2}} = 17100$ #/□" ✓

Unit Stress due to Vert. Loads $\frac{31700 \times 12}{35.0} = 10,870$ #/□" ✓

Horiz. Loads $\frac{2390 \times 12}{\frac{1}{2} \times 9.2} = 6230$

$17,100$ #/□"

Use 10" WF 33# ✓

Max. Shear due to Horiz. Thrust

$500 \times \frac{7.08}{12.25} + 500 = 788$ # ✓

25% Impact $= 197$

985 # ✓

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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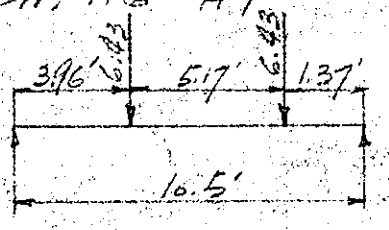
Subject Meadow Hill Pumping Sta. E46c

Computation Crane Beams

Computed by H. H. Z. Checked by [illegible] Date 5-1-31

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Bm A6 - A7



L.L. Moment $1286 \times \frac{3.96^2}{10.5} = 19200$ # ✓

25% Impact $= 4800$

D.L. Mom. $8 \times 50 \times 10.5 = 690$

$= 24690$ # ✓

Horiz. Thrust per Wheel = 500#

L.L. Moment (Lateral) $\frac{500}{6430} \times 24{,}000 = 1870$ # ✓

Try 10" WF 33# Flange 8" $S_{xx} = 35$ $S_{yy} = 9.2$

Allow. $f_s = \frac{20000}{1 + \frac{(126)^2}{2000 \times (8)^2}} = 17200$ #/□" ✓

Unit Stress due to Vert. Loads $\frac{24690 \times 12}{35} = 8470$ ✓

Horiz. Loads $\frac{1870 \times 12}{\frac{1}{2} \times 9.2} = 4880$

13,350 #/□"

Use 10" WF 33# ✓

Max. Shear due to Horiz Thrust

$500 \times \frac{5.33}{10.5} + 500 = 754$ ✓

25% Impact $= 189$

945 # ✓

WAR DEPARTMENT

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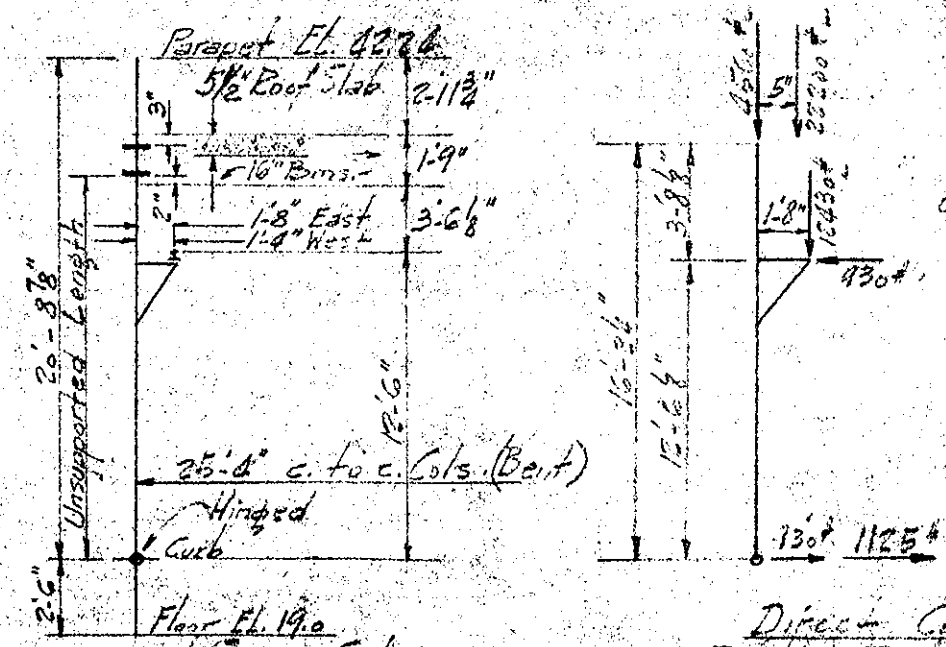
Subject Meadow Hill Pumping Sta. EH 6c

Computation Columns Column A2

Computed by W. W. Z. Checked by [illegible] Date 5-1-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Typical Crane Column

Crane Bracket Load

L.L. = 12860 × 7.42/10.00 = 9540#

25% Impact = 2385

Cr. Rail, Bm etc. = 500

12430#

Wind: 20 × 9.5 = 190#

{190 × 17.76 × ½ = 1685# (wall)

{190 × 2.97 = 565 (parapet)

2250#

Each Col. = 1125#

Direct Column Load

Reaction Roof Bm.	2400#
do	2160
do	22200
Bracket Load	12430
	39200#

Moment @ Bracket

22200 × 0.42 × 12.51/16.19 = 7230'#

12430 × 1.67 × 12.51/16.19 = 16100

930 × 12.51 = 11600

34930'#

Wind — 1125 × 12.51 = 14100'#

Try 10" WF 45# A = 13.24 S = 49.1 r = 2.00 L = 16'-2¼" = 194.3"

Allow $f_s = \dfrac{18000}{1 + \dfrac{\left(\frac{194.3}{2.00}\right)^2}{18000}}$ = 11800 #/□" or 1.33 × 11800 = 15700 #/□" for wind

Actual Stress $\dfrac{P}{A} = \dfrac{39200}{13.24}$ = 2960 #/□"

$\dfrac{M}{S} = \dfrac{34930 \times 12}{49.1}$ = 8540

11500 #/□" ok.

$\dfrac{M_1}{S} = \dfrac{14100 \times 12}{49.1}$ = 3440

14940 ok.

Use 10" WF 45#

WAR DEPARTMENT
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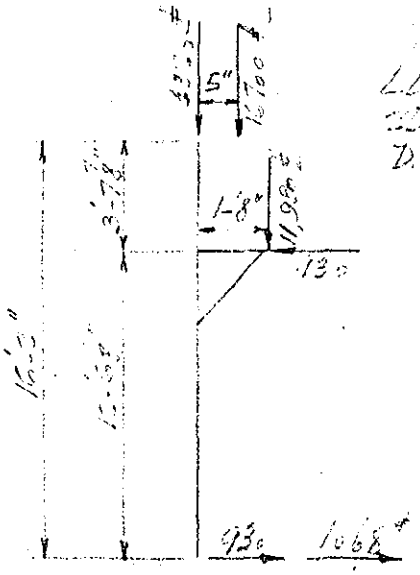
Subject [illegible]
Computation [illegible] Column A3
Computed by [illegible] Checked by [illegible] Date 5-[illegible]

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Crane Bracket Load –

LL 12860 × 6.47/9.00 = 9180#
25% Impact = 2295
D.L. Crane = 500
11380#

Wind: 20# × 9.0 = 180#
180 × 17.78 × 1/2 = 1600#
180 × 2.97 = 535
2135#
Each Column = 1068#

Column Load –
Reaction Bracket Bar = 2150#
do = 2000
do = 16700
Bracket = 11930
33,000#

Moment @ Bracket –
16700 × 0.42 × 12.51/16.17 = 5430'#
11980 × 1.67 × 12.51/16.17 = 15500
930 × 12.51 = 11600
32530'#

Wind
1068 × 12.51 = 13380'#

Try 10" WF 41# A = 12.06 S = 44.5 r = 1.99 L = 194.0

Allow $f_s = \dfrac{18000}{1 + \dfrac{\left(\frac{194.0}{1.99}\right)^2}{18000}} = \begin{cases} 11800\ \#/\square'' & \text{without wind or} \\ 11800 \times 1.33 = 15700\ \#/\square'' & \text{with wind} \end{cases}$

$\dfrac{P}{A} = \dfrac{33000}{12.06} = 2740\ \#/\square''$

$\dfrac{M}{S} = \dfrac{32530 \times 12}{44.5} = \dfrac{8770}{11510}\ \#/\square''$ without wind

$\dfrac{M_1}{S} = \dfrac{13380 \times 12}{44.5} = \dfrac{8670}{15120}\ \#/\square''$ with wind

Use 10" WF 41

WAR DEPARTMENT

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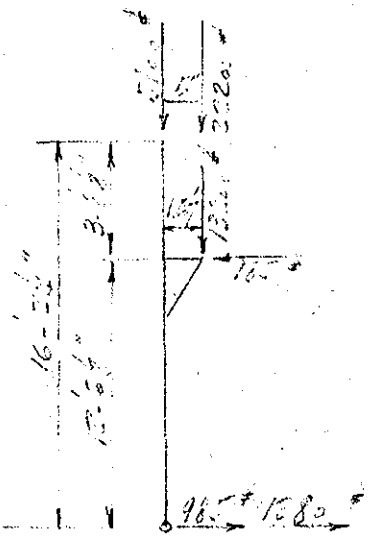
Subject Meadow Hill Pumping Sta. EH 60

Computation Crane Column A4

Computed by W. W. Z. **Checked by** [illegible] **Date** 5-1-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Crane Bracket - Load

L.L. = 12860 × 9.66/13.25 = 10140#

25% Impact = 2535

D.L. Rail, etc = 525

13200#

Wind: 20 × 2625 × ½ = 215#/ft

215 × 17.75 × ½ = 1910# (max)

215 × 2.97 = 640

2550#

Each Column = 1280#

Direct Column Load

Reaction Roof Sec. = 2940

d = 2160

d = 22200

Bracket = 13200

40500#

Moment @ Bracket

22200 × 0.42 × 12.51/16.19 = 7200'#

13200 × 1.67 × 12.51/16.19 = 17050

985 × 12.51 = 12320

36570#

Wind -

1280 × 12.51 = 16100'#

Top Wt. of 45#' A = 13.24 S = 49.1' r = 2.00" L = 194.5

Allow. f = 11800#/□" or 15700#/□" [illegible] (see [illegible])

Actual Stress

$\frac{P}{A} = \frac{4050}{13.24} = 3250$ #/□"

$\frac{M}{S} = \frac{36570 \times 12}{49.1} = \frac{8950}{12200}$ #/□" (no wind)

$\frac{M}{S} = \frac{16100 \times 12}{49.1} = \frac{3930}{16130}$ #/□" (with wind)

Use 10" [illegible] 49#

WAR DEPARTMENT

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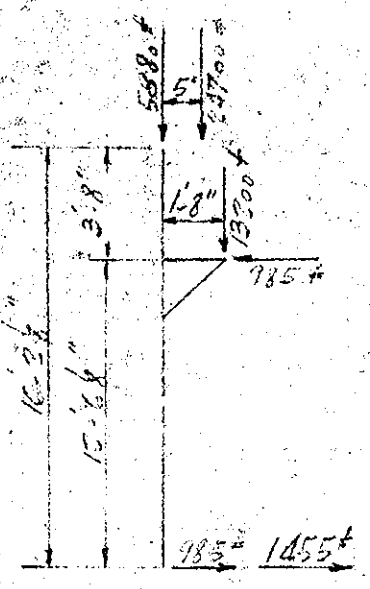
Subject: Meadow Hill Pumping Sta. EH 6c

Computation: Crane Column A5

Computed by: H. W. Z. Checked by: [illegible] Date: 5-1-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Crane Bracket Load

L.L. $12860 \times \frac{9.66}{12.25}$ = 10140

25% Impact = 2535

D.L., Rail, Etc. 525

13200 #

Wind: $20^{\#} \times 24.5' \times \frac{1}{2}$ = 245 #/'

$245 \times 17.76' \times \frac{1}{2}$ = 2180 #

$245 \times 2.97'$ = 730

2910 #

Each Column = 1455 #

Direct Column Load

Reaction Roof Bm. = 2940 #

do. = 2940

do. = 24700

Bracket = 13200

43780 #

Moment @ Bracket

$24700 \times 0.42 \times \frac{12.51}{16.18}$ = 8640 '#

$13200 \times 1.67 \times \frac{12.51}{16.18}$ = 17080 '#

985×12.51 = 12330

37450 #

Wind — $1455 \times 12.51 = 18200$ '#

Try 10" WF 49# A = 14.40 S = 54.6 r = 2.54 L = 194.2"

Allow $f_s = \dfrac{18000}{1 + \dfrac{\left(\frac{94.2}{2.54}\right)^2}{18000}}$ = 13600 #/□" (no wind) or 1.33×13600 = 18100 #/□" wind

Actual Stress: $\frac{P}{A} = \frac{43780}{14.40}$ = 3040 #/□"

$\frac{M}{S} = \frac{37450 \times 12}{54.6}$ = 8230

11270 #/□"

$\frac{M}{S} = \frac{18200 \times 12}{54.6}$ = 4000

15270

Use 10" WF 49#

WAR DEPARTMENT

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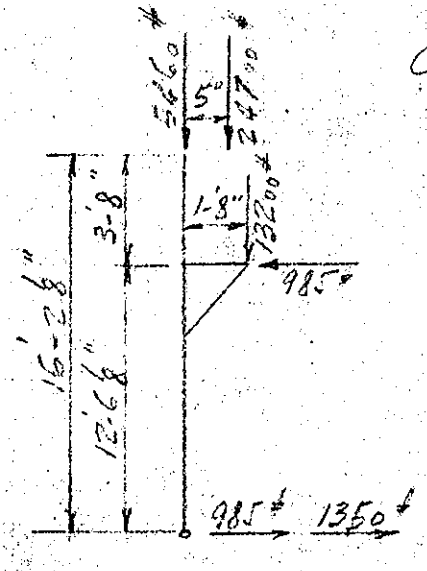
Subject Meadow Hill Pumping Sta.

Computation Crane Column A6

Computed by W. M. Z. Checked by [illegible] Date 5-2-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Crane Bracket Load (Sheet 10) = 13200

Wind: 20# × 22.75 × ½ = 228 #/ft

228 × 17.76 × ½ = 2020#

228 × 2.97 = 680

2700#

Each Column = 1350#

Moment @ Bracket –

24700 × 0.42 × 12.51/16.18 = 8040'#

13200 × 1.67 × 12.51/16.18 = 17080

985 × 12.51 = 12330

37450'#

Wind – 1350 × 12.51 = 16900'#

Direct Column Load –

Reaction Roof Bm	=	2940#
do	=	2520
do	=	24700
Bracket	=	13200
		43360#

Allow fs (10" WF 49#) = { 13600 #/□" without wind; 18100 #/□" with wind }

$\frac{P}{A} = \frac{43360}{14.40} = 3010$ #/□"

$\frac{M}{S} = \frac{37450 \times 12}{54.6} = 8240$

11250 #/□" without wind OK

$\frac{M}{S} = \frac{16900 \times 12}{54.6} = 3710$

14960 #/□" with wind OK

Use 10" WF 49#

WAR DEPARTMENT

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Object Meadow Hill Pumping Sta. EH 6c

Computation Crane Column, C2

Computed by W. W. Z. Checked by [illegible] Date 5-2-41

U.S. GOVERNMENT PRINTING OFFICE 3—10528

See Column A2

Direct Load = 39200 #

Moment @ Bracket

$22200 \times 0.42 \times \frac{12.51}{16.19} = 7830$ #

$12420 \times 1.33 \times \frac{12.51}{16.19} = 12800$

$930 \times 12.51 = 11630$

31660 #

Wind - $1125 \times 12.51 = 14100$ #

Try 10" WF 41 # A = 12.06 S = 44.5 r = 1.99 L = 194.3"

Allow fs = $\frac{18000}{1 + \frac{(194.3)^2}{1.99}} = \begin{cases} 11750 \text{ \#/□"} & \text{(without wind)} \\ 15650 & \text{(with wind)} \end{cases}$

$\frac{P}{A} = \frac{39200}{12.06} = 3250$ #/□"

$\frac{M}{S} = \frac{31660 \times 12}{44.5} = 8550$

11800 #/□" (without wind) O.K.

$\frac{M_1}{S} = \frac{14100 \times 12}{44.5} = 3800$

15600 #/□" (with wind) O.K.

Use 10" WF 41 #

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Meadow Hill Pumping Sta. EU 60

Computation: Crane Column C3

Computed by: W. W. Z. Checked by: [illegible] Date: 5-2-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528

See Column A3

Direct Column Load = 33000.#

Moment @ Bracket –

$16700 \times 0.42 \times \frac{12.51}{16.17} = 5430$ '#

$11980 \times 1.33 \times \frac{12.51}{16.17} = 12300$

$950 \times 12.51 = 11600$ '#

29330 '#

Mind –

$1068 \times 12.51 = 13380$ '#

For 10" WF 37# $A = 10.88$ $S = 39.4$ $r = 1.97$ $L = 194.0$

Allow $f_s = \dfrac{18000}{1 + \dfrac{\left(\frac{194.0}{1.97}\right)^2}{18000}} = \begin{cases} 11700 \text{ \#/□"} & \text{without wind} \\ 11700 \times 1.33 = 15600 \text{ \#/□"} & \text{with wind} \end{cases}$

$\frac{P}{A} = \frac{33000}{10.88} = 3040$ #/□"

$\frac{M}{S} = \frac{29330 \times 12}{39.4} = 8830$ #/□" without wind

$\frac{M_1}{S} = \frac{13380 \times 12}{39.4} = 4070$ #/□" with wind

Use 10" WF 41 #

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Meadow Hill Pumping Sta. EH 60 — Page 139

Computation: Crane Column "C4"

Computed by: W. W. Z. — Checked by: Vad jr. — Date: 5-2-41

U. S. GOVERNMENT PRINTING OFFICE 3—10523

See Column A4

Direct Column Load = 40500 # ✓

Moment @ Bracket –

$22200 \times 0.42 \times \frac{12.51}{16.19} = 7200$ '# ✓ Wind –

$13200 \times 1.33 \times \frac{12.51}{16.19} = 13600$ ✓ $1280 \times 12.51 = 16100$ '#

$985 \times 12.51 = 12320$ ✓

33120 '#

Try 10" WF 45#

Allow. f_c = 11800 #/□" without wind

15700 #/□" with wind

$\frac{P}{A} = \frac{40500}{13.24} = 3050$ #/□"

$\frac{M}{S} = \frac{33120 \times 12}{49.1} = \frac{8110}{11160}$ #/□" without wind

$\frac{M_1}{S} = \frac{16100 \times 12}{49.1} = \frac{3940}{15700}$ #/□" with wind ✓

Use 10" WF 45 ✓

WAR DEPARTMENT

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Subject Meadow Hill Pumping Sta EH 60

Computation Crane Column C5

Computed by W. W. Z. Checked by [illegible] Date 5-2-41

U. S. GOVERNMENT PRINTING OFFICE 3—10523

See Column A5

Direct Column Load —

Reaction Roof Bm	= 2940 #	e = 0'-8 3/8"
do	= 4450	e = 0"
do	= 24700	e = 5"
Bracket	= 13200	e = 2'-0 3/8"
	45290 #	

Moment @ Bracket —

$24700 \times 0.42 \times \frac{12.51}{16.18} = 8040$ '#

$13200 \times 2.03 \times \frac{12.51}{16.18} = 20800$

$2940 \times 0.70 \times \frac{12.51}{16.18} = 1590$

$985 \times 12.51 = 12330$

42760 '#

Wind —

$1700 \times 12.51 = 21300$ '#

Try 10" WF 49# A = 14.40 S = 54.6 r = 2.54 L = 194.2"

Allow f_b = 13600 #/□" without wind

18100 with wind

$\frac{P}{A} = \frac{45290}{14.40} = 3140$ #/□"

$\frac{M}{S} = \frac{42760 \times 12}{54.6} = 9400$

12540 #/□" without wind

$\frac{M_1}{S} = \frac{21300 \times 12}{54.6} = 4700$

17240 with wind

Use 10" WF 49

WAR DEPARTMENT

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Subject Meadow Hill Pumping Sta. EH 6c

Computation Crane Columns C6

Computed by W. W. Z. Checked by [illegible] Date 5-3-41

U. S. GOVERNMENT PRINTING OFFICE 3—10328

See Column A6

Direct Column Load –

Reaction Roof Bin	=	4450 # ✓	e = 0
do.	=	2520 ✓	e = 0'-8 3/8"
do.	=	24700 ✓	e = 5"
Bracket	=	13200 ✓	e = 2'-0 3/8"
		44870 # ✓	

Wind = 2020 # ✓

228 × 4.97 = 1130 ✓

3150 # × 1/2 = 1580 # at column ✓

Moment @ Bracket –

24700 × 0.42 × 12.51/16.18 = 8040 '#

13200 × 2.03 × 12.51/16.18 = 20800 ✓

985 × 12.51 = 12330 ✓

2520 × 0.70 × 12.51/16.18 = 1360 '#

42,530

Wind –

1580 × 12.51 = 19800 '#

Try 10" WF 49 A = 14.40 □" I = 54.6 □" r = 2.54 L = 194.2 "

Allow f_y = 13600 #/□" no wind or

13600 × 1.33 = 18100 #/□" with wind

Actual Stress –

$\frac{P}{A} = \frac{44870}{14.40} = 3100$ #/□"

$\frac{M}{I} = \frac{42,530 \times 12}{54.6} = 9370$

12470 #/□" no wind

$\frac{M_1}{I} = \frac{19800 \times 12}{54.6} = 4350$

16820 #/□" with wind

Use 10" WF 49 # ✓

WAR DEPARTMENT

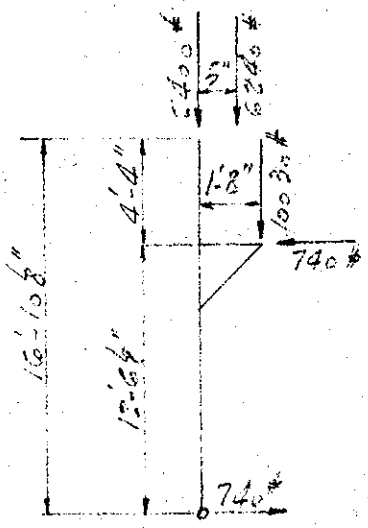
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

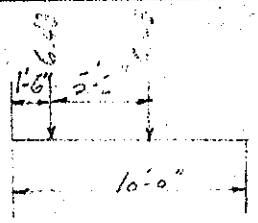
Subject: Meadow Hill Pumping Sta. EH 6c

Computation: Crane Column A1

Computed by: W. H. L. Checked by: [illegible] Date: 5-2-41

U. S. GOVERNMENT PRINTING OFFICE 3—10638





$\frac{5.92}{10.00} \times 1286 =$ 7620 # ✓

25% Impact = 1905 ✓

D.L. Roll, etc. = 500 ✓

10,030 # ✓

Horiz. Thrust $= \frac{5.92}{10.00} \times 1000 =$ 592 #

25% Impact = 148

740 # ✓

Wind Stress taken by walls.

Direct Column Load –

Reaction Roof Bm. = 2400 # ✓

do. = 6240 ✓

Bracket Load = 10030 ✓

1867 0 # ✓

Moment @ Bracket –

$6240 \times 0.42 \times \frac{12.51}{16.83} =$ 1950 '# ✓

$10030 \times 1.67 \times \frac{12.51}{16.83} =$ 12450 ✓

$740 \times 12.51 =$ 9270

23670 '# ✓

Try 10" WF 33# A = 9.71 □" S = 35.0 r = 1.94 L = 202.5" ✓

$$\text{Allow. } f_s = \frac{18000}{1 + \frac{\left(\frac{202.5}{1.94}\right)^2}{18000}} = 11200 \text{ \#/□"} \checkmark$$

Actual Stress

$$\frac{P}{A} = \frac{1867 0}{9.71} = 1920 \text{ \#/□"} \checkmark$$

$$\frac{M}{S} = \frac{23670 \times 12}{35.0} = 8110$$

10030 #/□" < f 11200 #/□" ✓

For 8" WF 31# A = 9.12 □" S = 27.4 r = 2.01 f_s = 11400 #/□" ✓

$$\frac{P}{A} = \frac{1867 0}{9.12} = 2050 \text{ \#/□"}$$

$$\frac{M}{S} = \frac{23670 \times 12}{27.4} = 10350$$

12400 #/□" > 11400 #/□"

Use 10" WF 33 ✓

WAR DEPARTMENT

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Subject: Meadow Hill Pumping Sta. EH 6c

Computation: Crane Columns C1

Computed by: W. W. Z. Checked by: [illegible] Date: 5-5-41

U. S. GOVERNMENT PRINTING OFFICE 3—10538

See Column A1.

Direct Column Load = 18670 # ✓

Moment @ Bracket –

$6260 \times 0.42 \times \frac{12.51}{16.83} = 1950'\#$ ✓

$1030 \times 1.33 \times \frac{12.51}{16.83} = 9900'$ ✓

$740 \times 12.51 = 9270$ ✓

$21130'\#$ ✓

Try 8" WF 31

Allow $f_s = 11400 \#/\square''$ ✓

$\frac{P}{A} = \frac{18670}{9.12} = 2050 \#/\square''$ ✓

$\frac{M}{S} = \frac{21130 \times 12}{27.4} = 9250$ ✓

$11300 \#/\square'' < 11400$ ✓ ok.

Use 8" WF 31 ✓

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Subject Meadow Hill Pumping Sta EH 6c

Computation Column B1 & B7

Computed by W. W. Z. **Checked by** [illegible] **Date** 5-5-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Direct Column Load -

Reaction Roof Bm. = 6240 #

do. = 6240

do. = 450

12930 #

Wind -

20 #/□' × 12.67 = 253 #/'

$M = \frac{1}{8} \times 253 \times (17.18)^2 = 9320$ '#

Try 8" WF 35# A = 10.30 S = 31.1 r = 2.03 L = 202.2"

$S_1 = 10.6$

$$\text{Allow } f_s = \frac{18000}{1 + \frac{\left(\frac{202.2}{2.03}\right)^2}{18000}} = 11600 \text{ \#/□"}$$

$$\frac{P}{A} = \frac{12930}{10.30} = 1260 \text{ \#/□"}$$

$$\frac{M}{S_1} = \frac{9320 \times 12}{10.6} = 10600$$

11900 #/□" ok.

Use 8" WF 35

Column B7 (Similar to above)

Direct Column Load = 13050 #

Wind Moment = 9320 #

For 8" WF 35 Allow. f_s = 11600 #/□"

$$\frac{P}{A} = \frac{13050}{10.30} = 1270 \text{ \#/□"}$$

$$\frac{M}{S_1} = 10600$$

11900 #/□" ok.

Use 8" WF 35

WAR DEPARTMENT

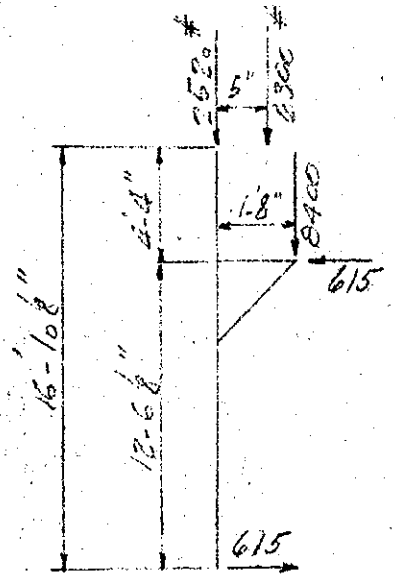
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

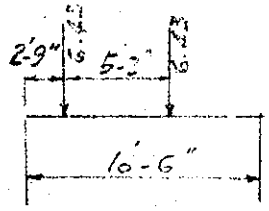
Subject Meadow Hill Pumping Sta. EH 60

Computation Crane Columns A7

Computed by W. M. Z. **Checked by** [illegible] **Date** 5-5-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528





$\frac{5.17}{10.5} \times 13860 = 6320\#$

25% Impact = 1580

D.L. = 500

8400 #

Horiz. Thrust = $\frac{5.17}{10.5} \times 1000 = 492$

25% Impact = 123

615 #

Direct Column Load

Reaction Roof Bm = 2520 #

do. = 6300

Bracket Load = 8400

17220 #

Moment @ Bracket

$6300 \times 0.42 \times \frac{12.51}{16.83} = 1970$ '#

$8400 \times 1.67 \times \frac{12.51}{16.83} = 10400$

$615 \times 12.51 = 7700$

20070 '#

Try 10" WF 33 A = 9.71 S = 35.0 r = 1.94 L = 20'-2"

Allow $f_s = \frac{18000}{1 + \frac{\left(\frac{20.2}{1.94}\right)^2}{18000}} = 11200$ #/□"

$\frac{P}{A} = \frac{17220}{9.71} = 1775$ #/□"

$\frac{M}{S} = \frac{20070 \times 12}{35.0} = \frac{6875}{8650} < 11200$ #/□"

Use 10" WF 33 ✓

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject Meadow Hill Pumping Sta. EH-6c

Computation Crane Column C7

Computed by W. W. Z. Checked by W. A. Jr. Date 5-5-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528

See Column A7

Direct Column Load = 17220 #

Moment @ Bracket –

$6300 \times 0.42 \times \frac{12.51}{16.84} = 1970$ '#

$8400 \times 1.33 \times \frac{12.51}{16.84} = 8300$

$615 \times 12.51 = 7700$ '#

17970 '#

Try 8" WF 31

Allow f_s = 11400 #/□"

$\frac{P}{A} = \frac{17220}{9.12} = 1890$ #/□"

$\frac{M}{S} = \frac{17970 \times 12}{27.4} = 7870$ #/□"

9760 #/□" > 11400 ok.

Use 8" WF 31# ✓

WAR DEPARTMENT

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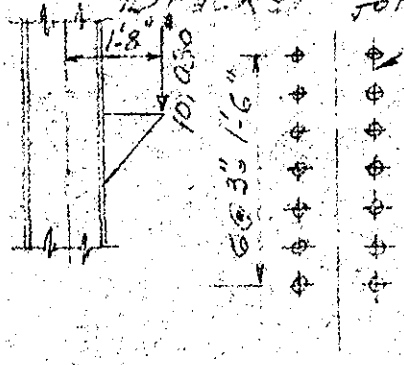
Subject Meadow Hill Pumping Sta. EH 6

Computation Crane Brackets

Computed by W. N. Z. Checked by [illegible] Date 5-6-41

U.S. GOVERNMENT PRINTING OFFICE 3—10528

Bracket for Column A1



Rivets in Column Flange

Let S = Rivet Stress then

$2 \times 2 \times 9.0\,S = 36.0\,S$

$2 \times 2 \times \frac{(6.0)^2}{9} S = 16.0\,S$

$2 \times 2 \times \frac{(3.0)^2}{9} S = 4.0\,S$

$56.0\,S$

$56.0\,S = 10{,}030 \times (20 - 4\tfrac{1}{2}) = 152{,}000''\#$

$S = 2710\#$

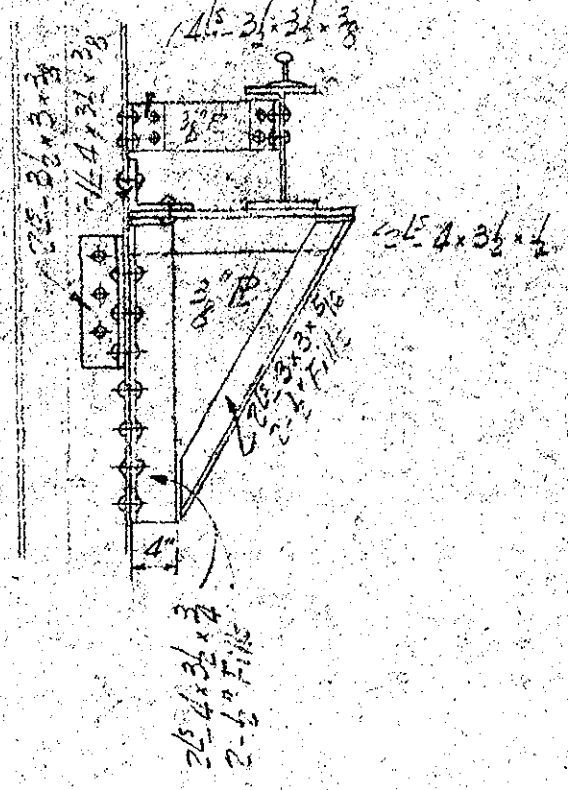
Vert. Shear on each rivet $= \frac{10{,}030}{14} = 720\#$

Stress on outermost rivet $\sqrt{(2710)^2 + (720)^2} = 2800\#$

Allow. Stress for $\frac{3}{4}''$ rivet $= 0.4418 \times 13500 = 5960\#$

Use 50% of 5960 or 2980# > 2800 O.K.

Use 14 rivets



For Columns

A1 - A7

C1 - C7

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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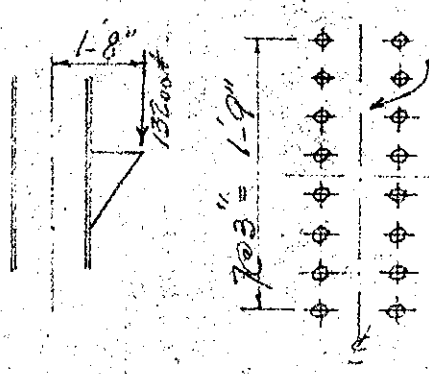
Subject: Meadow Hill Pumping Sta EH Co

Computation: Crane Bracket

Computed by: W. W. Z. Checked by: [illegible] Date: 5-6-41

U.S. GOVERNMENT PRINTING OFFICE 3—10528

Bracket for Column A5



Let s = Rivet Stress

$2 \times 2 \times 10.5\ s = 42.0\ s$ ✓

$3 \times 2 \times \frac{(7.5)^2}{10.5}\ s = 31.4\ s$ ✓

$2 \times 2 \times \frac{(4.5)^2}{10.5}\ s = 7.7\ s$ ✓

$2 \times 2 \times \frac{(1.5)^2}{10.5}\ s = 0.9\ s$ ✓

$72.0\ s$ ✓

$13200 \times 15'' = 72.0\ s$ ✓ $s = 2750\ \#/\text{rivet}$

Shear per Rivet $= \frac{13200}{16} = 825\ \#$ ✓

Max. Rivet Stress $= \sqrt{(2750)^2 + (825)^2} = 2870\ \#$ ✓

Allow. Stress for ¾" rivet $= 0.4418 \times 13500 = 5960\ \#$ ✓

50% Allow. Stress $= 2980\ \# > 2870$ OK. ✓

Use 16 Rivets ✓

For Columns A2-A3-A4-A5-A6 ✓
use 16 rivets in column flange

See sketch — Similar to A7

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

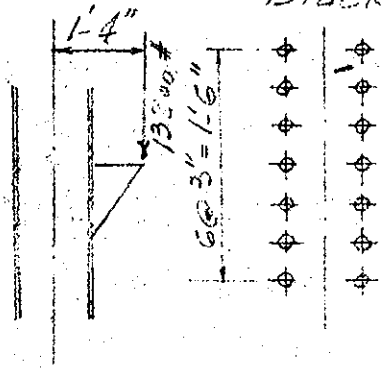
Subject Meadow Hill Pumping Sta. EH 50

Computation Crane Bracket

Computed by W. W. Z. **Checked by** [illegible] **Date** 4-6-41

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Bracket for Column C4



Rivets in Column Flange

Let S = River Stress

$2 \times 2 \times 9.0\,S = 36.0\,S$ ✓

$2 \times 2 \times \frac{(6.0)^2}{9.0} S = 16.0\,S$ ✓

$2 \times 2 \times \frac{(3.0)^2}{9.0} S = 4.0\,S$ ✓

$56.0\,S$ ✓

$36.0\,S = 13200 \times 10.94$

$S = 2580\#$ ✓

Vert. Shear on each rivet $= \frac{13200}{14} = 945\#$ ✓

Stress $= \sqrt{(2580)^2 + (945)^2} = 2750\#$ ok. ✓

Use 14 Rivets

For Columns C2-C3-C4 use 14 Rivets in Column Flange. ✓

See sketch for Column A7

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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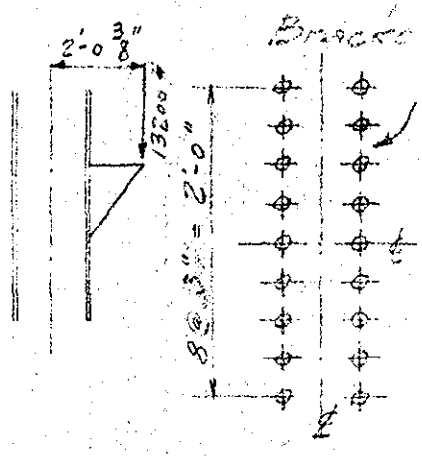
Subject Meadow Hill Pumping Sta.

Computation Crane Bracket

Computed by W. W. Z. **Checked by** [illegible] **Date** 5-6-41

U.S. GOVERNMENT PRINTING OFFICE 3—10528

Bracket for Column C5 & C6



Rivets in Column Flange

Let s = River Stress

$2 \times 2 \times 12.0\ s = 48.0\ s$ ✓

$2 \times 2 \times \frac{(9.0)^2}{12}\ s = 27.0\ s$ ✓

$2 \times 2 \times \frac{(6.0)^2}{12}\ s = 12.0\ s$ ✓

$2 \times 2 \times \frac{(3.0)^2}{12}\ s = 3.0\ s$ ✓

$90.0\ s$ ✓

$90.0\ s = 13200 \times 19.38 \qquad s = 2840\#$ ✓

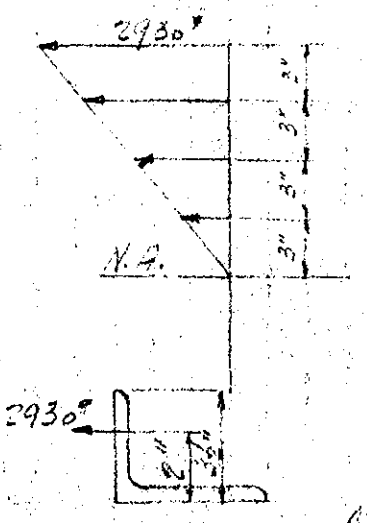
Vert. Shear/Rivet $= \frac{13200}{18} = 735\#$ ✓

Stress/Rivet $= \sqrt{(2840)^2 + (735)^2} = 2930\#$ ✓

50% Allow. Stress per 3/4" ⌀ rivet = 2980 ✓

$2930 < 2980$ ok. ✓

Use 18 Rivets ✓



Moment –

$2930 \times 12 = 35200''\#$ ✓

$2930 \times \frac{81}{12} = 19800$ ✓

$2930 \times \frac{36}{12} = 8800$ ✓

$2930 \times \frac{9}{12} = 730$ ✓

$64530''\#$

$S = \frac{M}{f_s} = \frac{64530}{18000} = 3.58''^3$ required

Assume $4 \times 3\frac{1}{2} \times \frac{3}{4}$ ∠

$S = \frac{1}{6} b h^2$

$b = 3''$ (rivet spacing)

$h = \frac{3}{4}''$

Moment $= 2930'(2 - \frac{3}{4}) = 3660''\#$ ✓ $\qquad S = \frac{1}{6} \times 3 \times \frac{9}{16} = \frac{9}{32}''$

$f_s = \frac{3660}{9/32} = 13000\#/\square'' < 18000$ ok. ✓

Use $4'' \times 3\frac{1}{2}'' \times \frac{3}{4}''$ ∠s ✓

Plate thickness –

$\frac{3}{4}(t) \times 24000 = 2930$

$t = \frac{2930}{24000} \times \frac{4}{3} = 0.163''$ ✓ Use 3/8" Plate ✓

See Sketch – Similar to A7