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STREAM POLLUTION ABATEMENT BY SUPPLEMENTAL PUMPING

Carl W. Reh, et al

Richmond City Department of Public Utilities

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16. ABSTRACT

At the Richmond, Virginia, Wastewater Treatment Plant, a major structure, i.e., a Supplemental Pumping Station, and several ancillary structures were provided to achieve the project objective of no bypassing while a new grit chamber was being connected ahead of the existing Main Pumping Station, which station received and pumped all of the raw sewage. The Supplemental Pumping Station was constructed by sinking a two-compartment, sheet steel cofferdam around an existing 72-inch concrete sewer and rearranging the influent sewer flow pattern so that the sewage was redirected to the site of the Supplemental Pumping Station. The redirection of sewage flow was achieved by the reconstruction of a junction chamber and by the insertion of a specially designed removable bulkhead, all without bypassing sewage. The time required for the design, construction and operation of the Supplemental Pumping Station was about 36 months and the cost of this project was approximately $900,000.

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STREAM POLLUTION ABATEMENT BY SUPPLEMENTAL PUMPING

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Department of Public Utilities
Richmond, Virginia 23219

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FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

This report describes the construction and operation of a Supplemental Pumping Station that was installed at the Richmond (Virginia) Wastewater Treatment Plant. The use of this station made it possible to continue plant operation while new plant units were being installed.

A. W. Breidenbach, Ph.D.
Director
National Environmental
Research Center, Cincinnati

ABSTRACT

In past times, the insertion of a major element into an existing sewage treatment plant was accomplished by taking the plant out of service and bypassing sewage during the cut-in period. It is possible to insert new plant units in major sewage treatment works without bypassing; however, avoidance of bypassing may require the construction of other major facilities.

At the Richmond, Virginia Wastewater Treatment Plant, (Annual Average Capacity = 70 mgd) a major structure, i. e., a Supplemental Pumping Station, and several ancillary structures were provided to achieve the project objective of no bypassing while a new grit chamber was being connected ahead of the existing Main Pumping Station, which station received and pumped all of the raw sewage.

The Supplemental Pumping Station was constructed by sinking a two-compartment, sheet steel cofferdam around an existing 72-inch concrete sewer and rearranging the influent sewer flow pattern so that the sewage was redirected to the site of the Supplemental Pumping Station. The redirection of sewage flow was achieved by the reconstruction of a junction chamber and by the insertion of a specially designed removable bulkhead, all without bypassing sewage.

The time required for the design, construction and operation of the Supplemental Pumping Station was about 36

months. The cost of design, construction and operation was about $900,000.00, of which $282,022.00 was provided by a EPA Demonstration Grant.

This report is submitted in fulfillment of Research, Development and Demonstration Grant 11022FLV, Construction Grants WPC-VA-248 and WPC-VA-273 from the Environmental Protection Agency to the City of Richmond, Virginia.

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FIGURES

FIGURES (Continued)

FIGURES (Continued)

TABLES

Acknowledgements

This project was financially supported by the City of Richmond, Virginia, and by grants from the Environmental Protection Agency.

Messrs. Harold J. Snyder, Jr. and Fenton Roudabush were the Project Officers for the Office of Water Programs of the Environmental Protection Agency. Mr. Snyder was instrumental in assisting the City in securing the Research and Demonstration Grant and Mr. Roudabush was most cooperative in assisting the City with the administration of this project.

Staff personnel of both the Department of Health and the Water Control Board of the Commonwealth of Virginia were most helpful during the entire period that this Research and Demonstration Project was conducted.

We wish to extend our sincere appreciation to both Contractors who worked on the project; Potter and Parsons, Inc., Baltimore, Maryland, who furnished the pumping equipment and the English Construction Company, Inc., Altavista, Virginia, who constructed the Supplemental Pumping Station and installed the equipment. The English Construction Company also constructed all the other appurtenant work necessary to make connections between existing facilities and the new Grit Chamber and also between the existing primary treatment plant and secondary treatment works.

Greeley and Hansen of Chicago, Illinois, were the Consulting Engineers responsible for the design of the Research and Demonstration project and assisted in the supervision of the construction of these facilities.

The project was under the direction of Mr. H. E. Lordley, Director of the Department of Public Utilities of the City of Richmond, who was ably assisted by Mr. G. M. Delano, Chief, Utility Plants, and Mr. L. H. Roden, Jr., Chief, Division of Wastewater Treatment. Mr. Roden was the City's Project Coordinator for this project.

SECTION I

CONCLUSIONS

1. The project demonstrates that it is possible to cut in a major sewage treatment plant element without the need for bypassing raw sewage.
2. Where no special provisions have been made either in the existing works or in the design of the new facilities for cutting in major plant elements without bypassing, special design will be required to achieve the "no bypassing" objective. In the case of this project, the special design required principally the supplemental pumping station and the construction of a unique bulkhead with a built-in sluice gate.
3. Pumping units of standard design can be used. The pumping units which were selected were variable speed motor driven vertical centrifugal pumps.
4. A two compartment sheet steel cofferdam is a feasible means for constructing a pumping station substructure around an existing sewer.
5. The time for design and construction of so-called temporary facilities is likely to approach that required for conventional facilities.
6. Reliable operation can be achieved through the design of simple mechanical configurations. The total control was: pump-on, pump-off, and pump-speed. Suction or discharge valves were not operated as a part of the

start-stop sequence.

7. Variable speed pump operation is feasible without a wet well. The close control of pumping levels, however, is difficult to achieve and requires more than ordinary attention.

8. Provisions should be included for large debris from finding its way into the pump suction through unanticipated water levels. Large garbage cans and tires succeeded in finding their way behind the coarse bar racks and interfered briefly with pumping operations.

9. The degree of treatment of sewage was maintained throughout the construction period.

10. No deterioration in the water quality in the James River was experienced throughout the construction period.

11. The scheduled bypassing time for the construction of the grit chamber was 110 calendar days. The time required to design, construct and operate the supplemental pumping station was 36 months. The total sewage pumped was 13,125 mg.

12. The cost of the new grit chamber was approximately $1.8 million. The cost of the supplemental pumping station and appurtenant work was $900,000. This amount included the cost of design, construction and operation. If all costs of the supplemental pumping station are applied to the cost of pumping sewage, the amount would be $65.54 per million gallons.

SECTION II

RECOMMENDATIONS

1. This demonstration was necessary because of a change in Federal guidelines. At the time a new grit chamber was scheduled to be connected to the sewage treatment works, the Federal guidelines were revised to prohibit any bypassing of raw sewage to receiving waterways As a result, the use of the new grit chamber was delayed about 36 months until a supplementary pumping station could be designed and constructed and the necessary connecting works completed. It is recommended, therefore, that, to the maximum extent possible, any project approved under one set of guidelines, and for which the major construction has been accomplished, be allowed to be completed under those guidelines rather than be conformed to a new set of criteria.

2. The project demonstrated that new plant facilities can be cut into an existing plant without the need for bypassing. The delays in the completion of the new works demonstrated the need to include those facilities for the avoidance of bypassing among the provisions for cut-in included as part of the original design. Such facilities should not be made a separate element of work.

3. If supplemental pumping is required, the facilities for such supplemental pumping should be included as a part of the general plant construction. A greater selection of pumping equipment will thereby be made available and the time for construction and for pumping will be coincident with the general plant construction and will not be made a sequential item of work. The cost for such supplemental facilities will be reduced by this procedure.

4. Pump control is basic to the operation of the supplemental pumping station. Usual automatic controls are not adequate for a pumping facility which has no wet well. It is necessary that a single level be defined for the control of all pumps at all speeds. Such a set point controller will facilitate automatic operation and will avoid problems in pump speed setting.

5. If a supplemental pumping station is to be strictly a one-time temporary pumping station, simpler configurations for the substructure should be explored to reduce both the time and the cost. Multiple smaller circular cofferdams may be feasible and if the time for the exploration of pump types is available, some form of a vertical wet pit type dredge pump might be

suspended within the cofferdam. These elements may tend to reduce time and cost.

6. The supplemental pumping station was planned to function about 110 days while the new grit chamber was being cut into the system. It was to be maintained on a standby basis should some future contingency require its reactivation. If a supplemental or a standby pumping station is to be maintained for the total life of the treatment works, the substructure should be large enough to accommodate equipment for all the future sewage quantities to be expected. The design concept might be different from the one which has been constructed. The function of a proposed supplemental pumping station should be fully explored and developed prior to the start of design.

SECTION III

INTRODUCTION

A. The Problem

The Richmond Sewage Treatment Plant was designed during the early 1950's and placed in operation in 1958. Most plants of this age had no means of routing sewage around its main pumping station without bypassing raw sewage. The practice of bypassing has always been permitted in the past throughout the country.

The City of Richmond is engaged in making certain additions to, and improvements in, its sewage treatment works. Figure 1 shows the relationship of the Wastewater Treatment Plant to the City of Richmond. Specifically, a new grit removal chamber now completed had to be connected to the plant's main pumping station which lifts all sewage into the plant. The grit removal chamber was constructed at a cost of $1.3 million, including a 30 percent EPA grant. Photographs of the new Grit Facilities are shown in Figures 2 and 3. The City also has secondary treatment facilities under construction which had to be connected to the present primary treatment plant at several locations. These secondary treatment facilities had also been approved for EPA grant participation. In addition, due to the severe flood in August, 1969, which inundated much of the treatment works, certain cleaning and

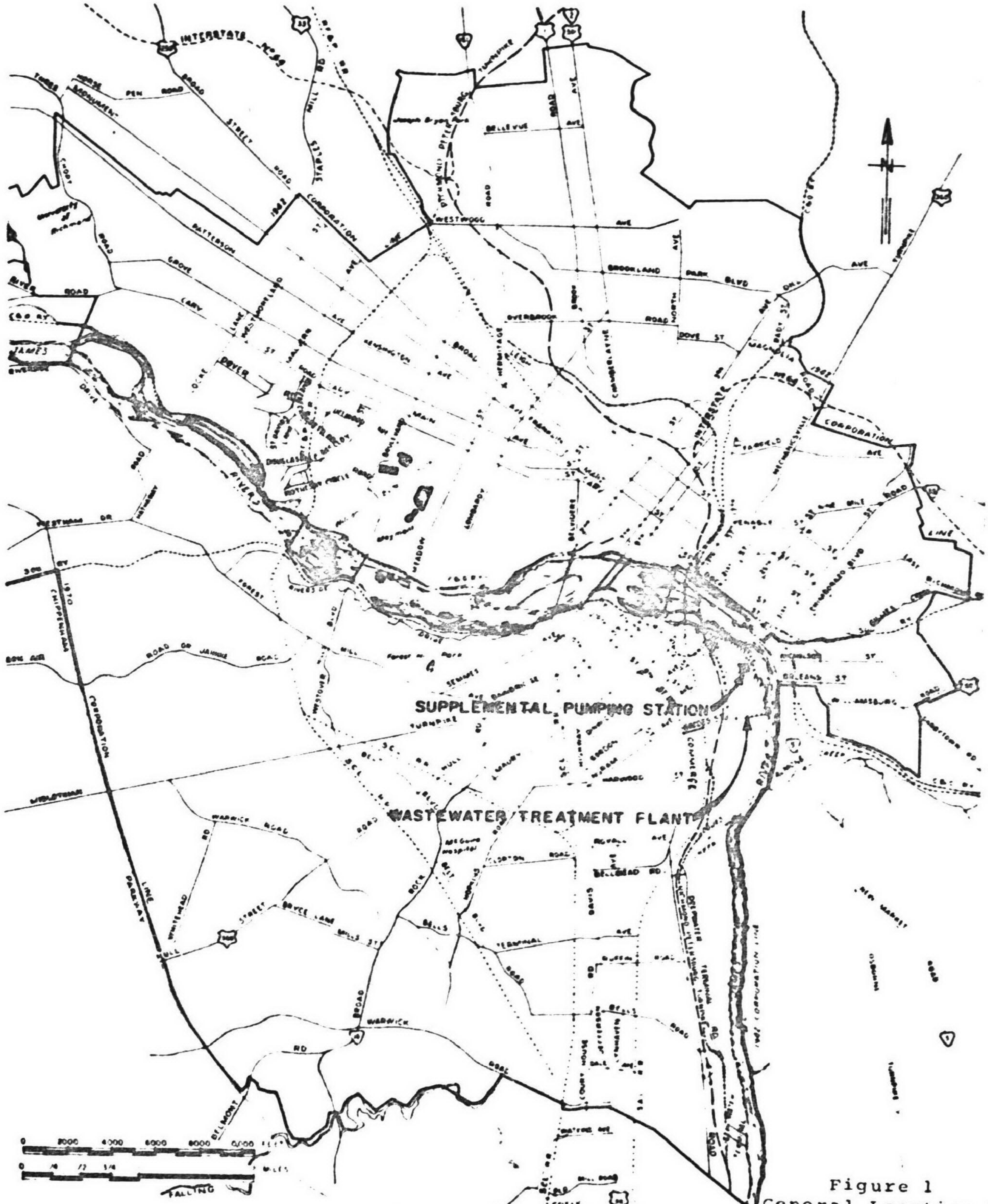


Figure 1
General Location Ma

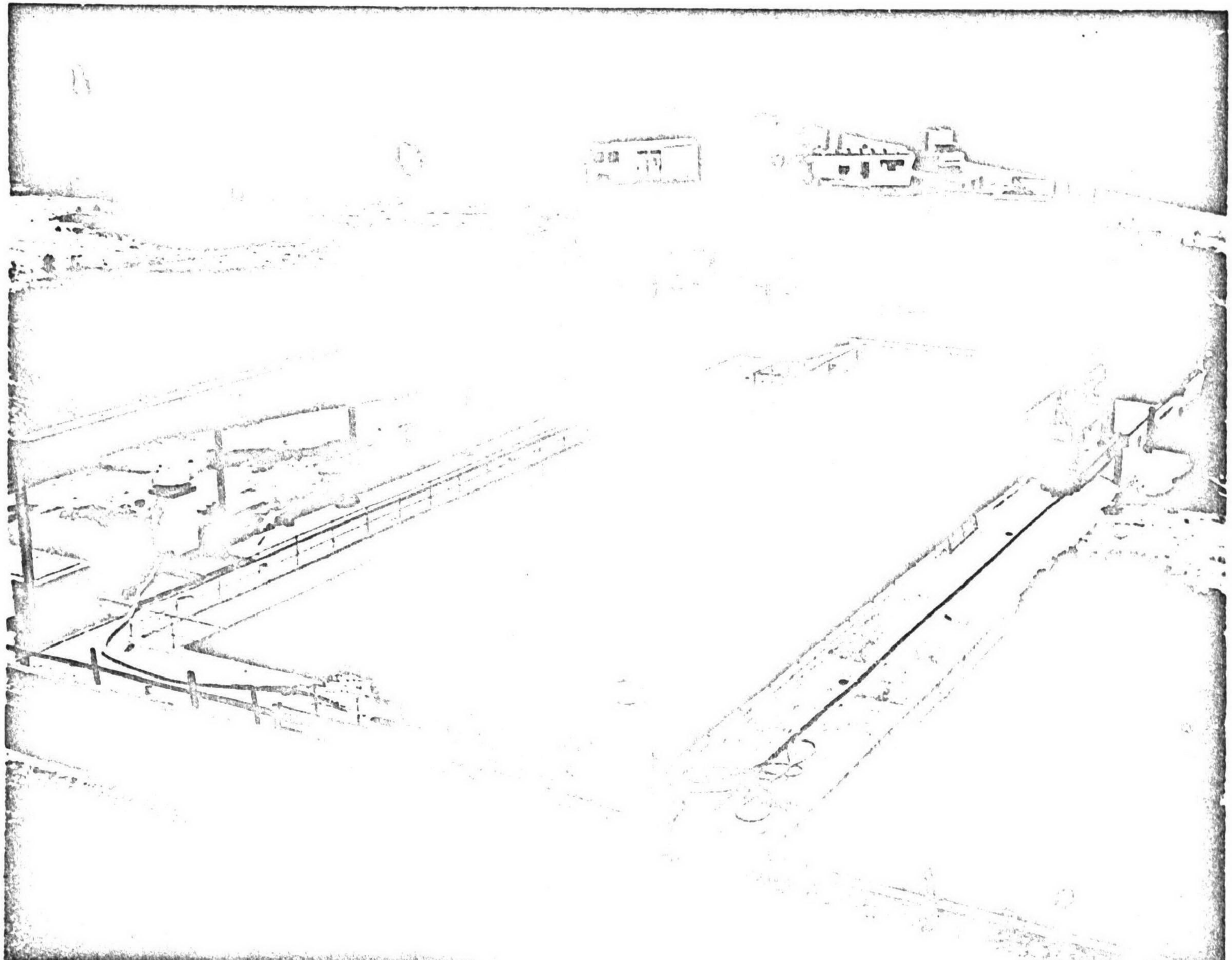


Figure 2
Grit Removal Facilities
View of New Grit Removal Facilities

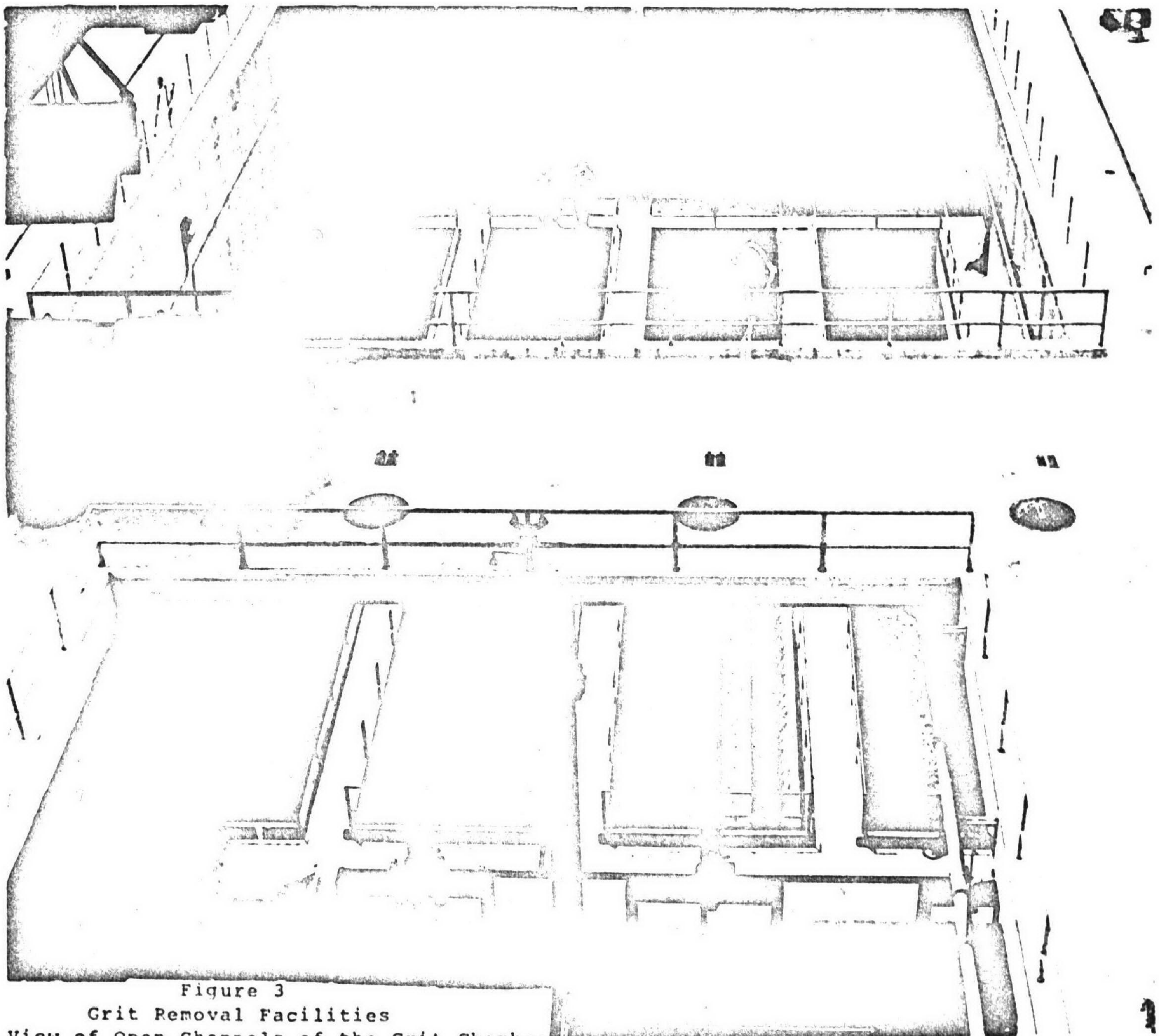


Figure 3
Grit Removal Facilities
View of Open Channels of the Grit Chamber

maintenance operations had to be performed.

The grit chamber was projected to be completed by November 1, 1969, and it was planned to cut in the new facilities during a 110-day period beginning on that date. During this 110-day period, the normal dry weather sewage flow of approximately 30 million gallons per day would be chlorinated and discharged directly into the James River, thereby bypassing the plant. The Virginia Water Control Board had approved the proposed plan. Prior approval had also been obtained from the U.S. Environmental Protection Agency in 1967 as part of its review of the City's plans for the construction of the grit removal facility and the initiation of construction of the secondary treatment works.

The Regional Director of the Federal Water Pollution Control Agency announced in September, 1969, that his Agency was opposed to the bypass. He stated that he would initiate action to prohibit the City from bypassing sewage into the James River and would oppose further Federal funding of Richmond's sewage treatment works if this were done.

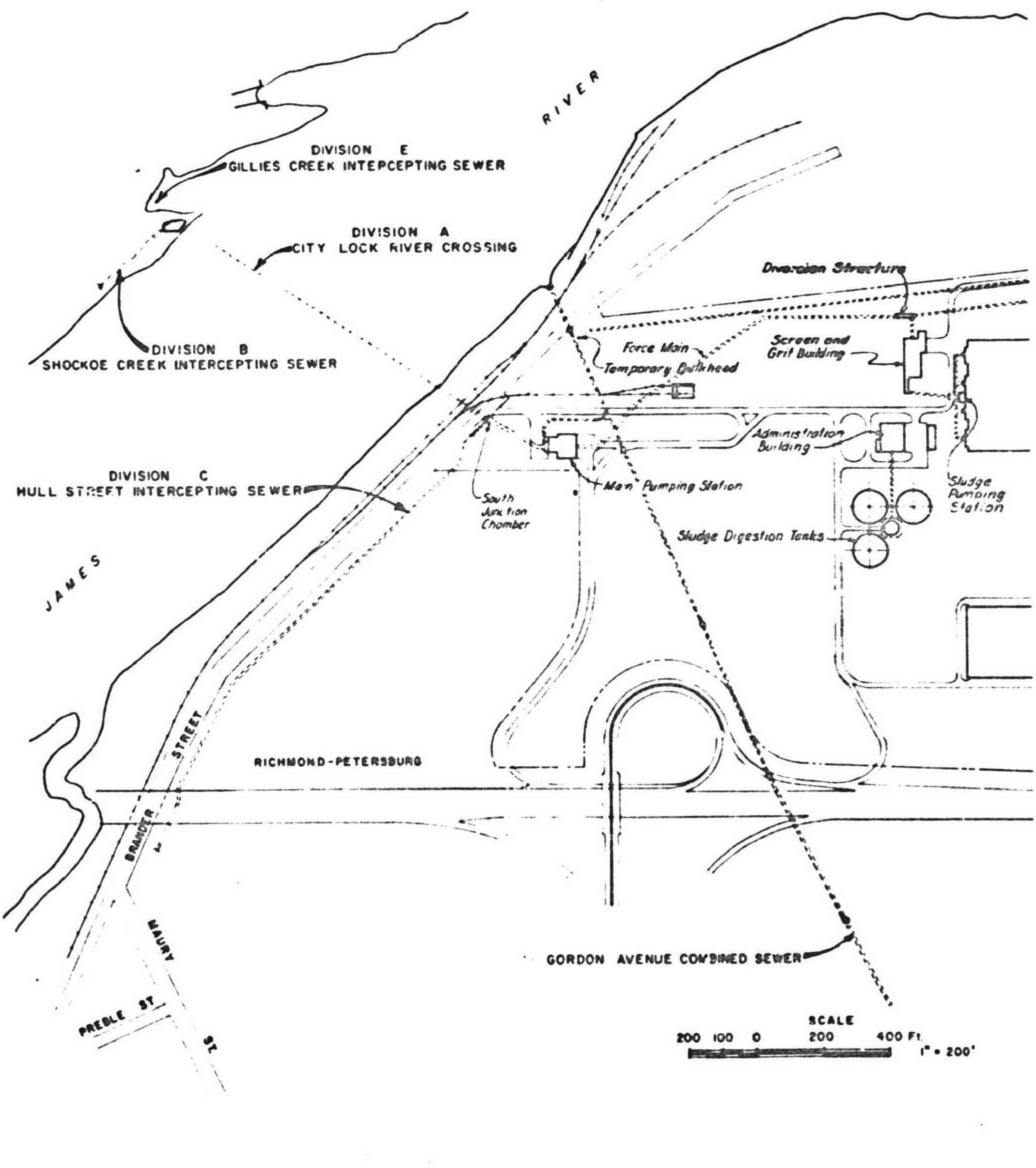
This new public policy prohibiting plant shutdown and bypassing provided a complete departure from the procedure previously approved by the Regulatory Agencies, and created a new problem for the City in that no provision had been made in the design for the connection of the new plant elements without a plant shutdown. The City accepted the new policy and directed its engineers, Greeley and Hansen, to develop schemes whereby the necessary work could be accomplished without bypassing sewage into the James River.

B. The System

Figure 1 shows a general location map of the Richmond area. Figure 4 shows the major sewers entering the Wastewater Treatment Plant. Figure 5 shows the arrangement of the sewers and plant structures in the vicinity of the Main Pumping Station prior to the construction of the new grit removal facilities. Figure 6 illustrates a flow diagram to accomplish temporary bypassing of plant facilities during the construction of the connecting conduits for the new grit chambers.

Two alternative methods were devised which would permit the connection of the new grit removal facilities without plant shutdown and without bypassing the raw sewage into the James River.

1. Alternate A comprised the installation of a 60-inch temporary bypass around the inlet conduit to the pumping station from the new diversion chamber to the inlet of the Main Pumping Station. A temporary bulkhead would be required to be installed at the outlet of the south junction chamber. Temporary bulkheads were also required at the entrance to the Main Pumping Station. If this arrangement could be provided, the plant could be kept in operation, using the existing Main Pumping Station, while the new grit removal


RIVER
DIVISION E
GILLIES CREEK INTEPCEPTING SEWER
DIVISION A
CITY LOCK RIVER CROSSING
DIVISION B
SHOCKOE CREEK INTERCEPTING SEWER
Diversion Structure
Screen and Grit Building
Force Main
Temporary Bulkhead
Administration Building
DIVISION C
HULL STREET INTERCEPTING SEWER
Main Pumping Station
South Junction Chamber
Sludge Pumping Station
Sludge Digestion Tanks
JAMES
RICHMOND-PETERSBURG
BRANDER STREET
MAURY ST.
PREBLE ST
GORDON AVENUE COMBINED SEWER
SCALE
200 100 0 200 400 Ft.
1" = 200'

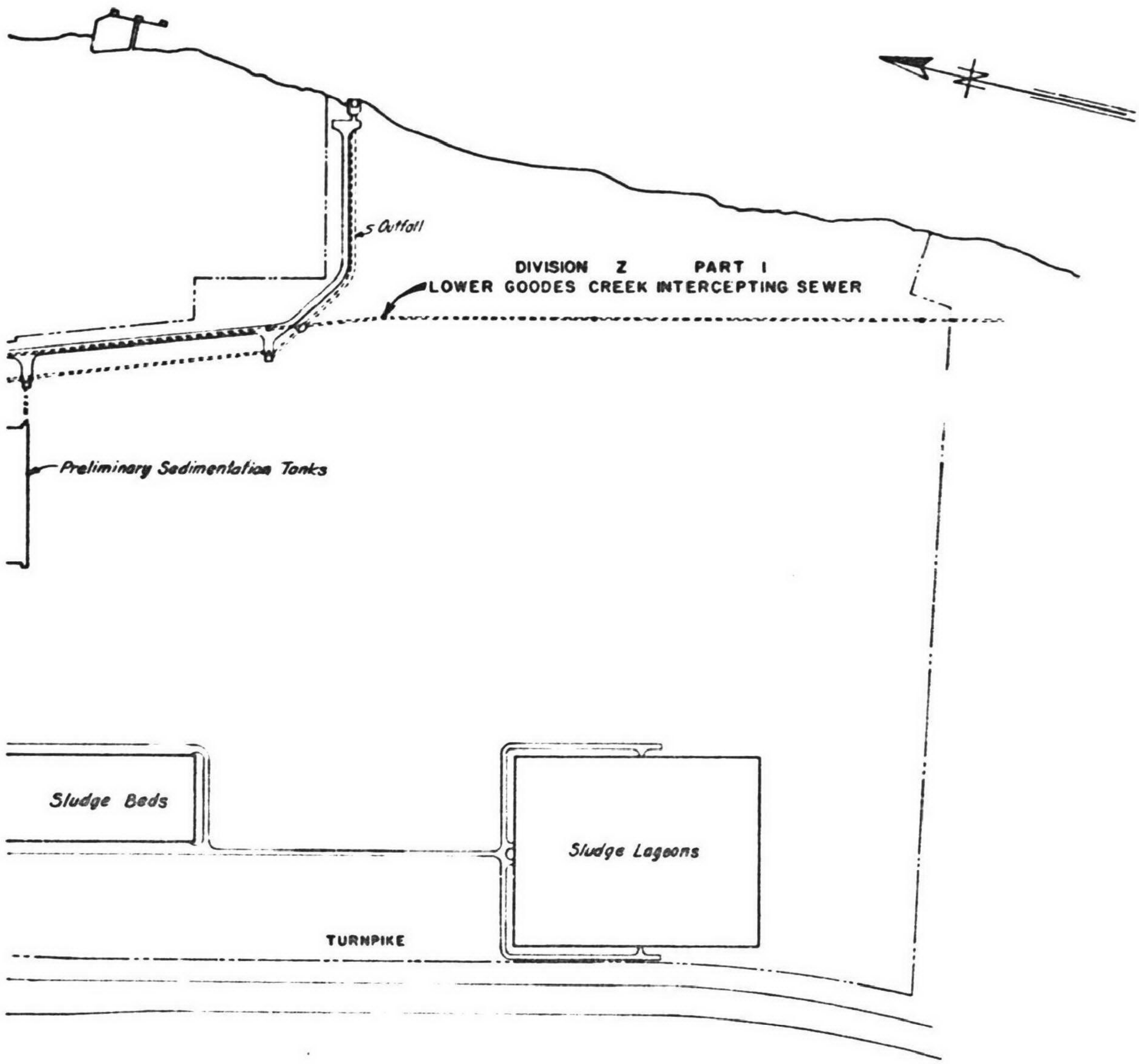
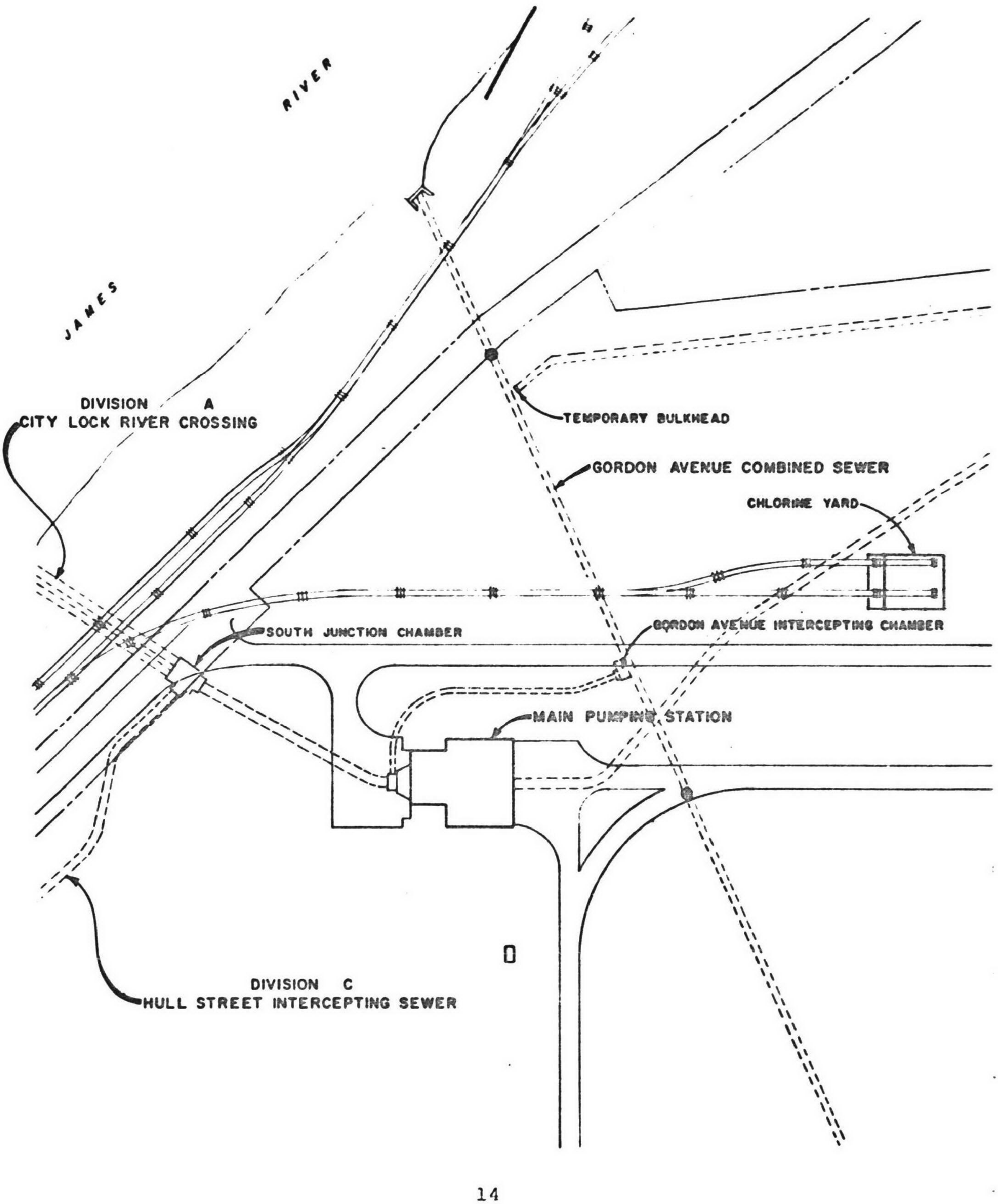


FIGURE 4

TRIBUTARY INTERCEPTING SYSTEM

AND

TREATMENT PLANT FACILITIES


JAMES
RIVER
DIVISION A
CITY LOCK RIVER CROSSING
TEMPORARY BULKHEAD
GORDON AVENUE COMBINED SEWER
CHLORINE YARD
SOUTH JUNCTION CHAMBER
GORDON AVENUE INTERCEPTING CHAMBER
MAIN PUMPING STATION
DIVISION C
HULL STREET INTERCEPTING SEWER

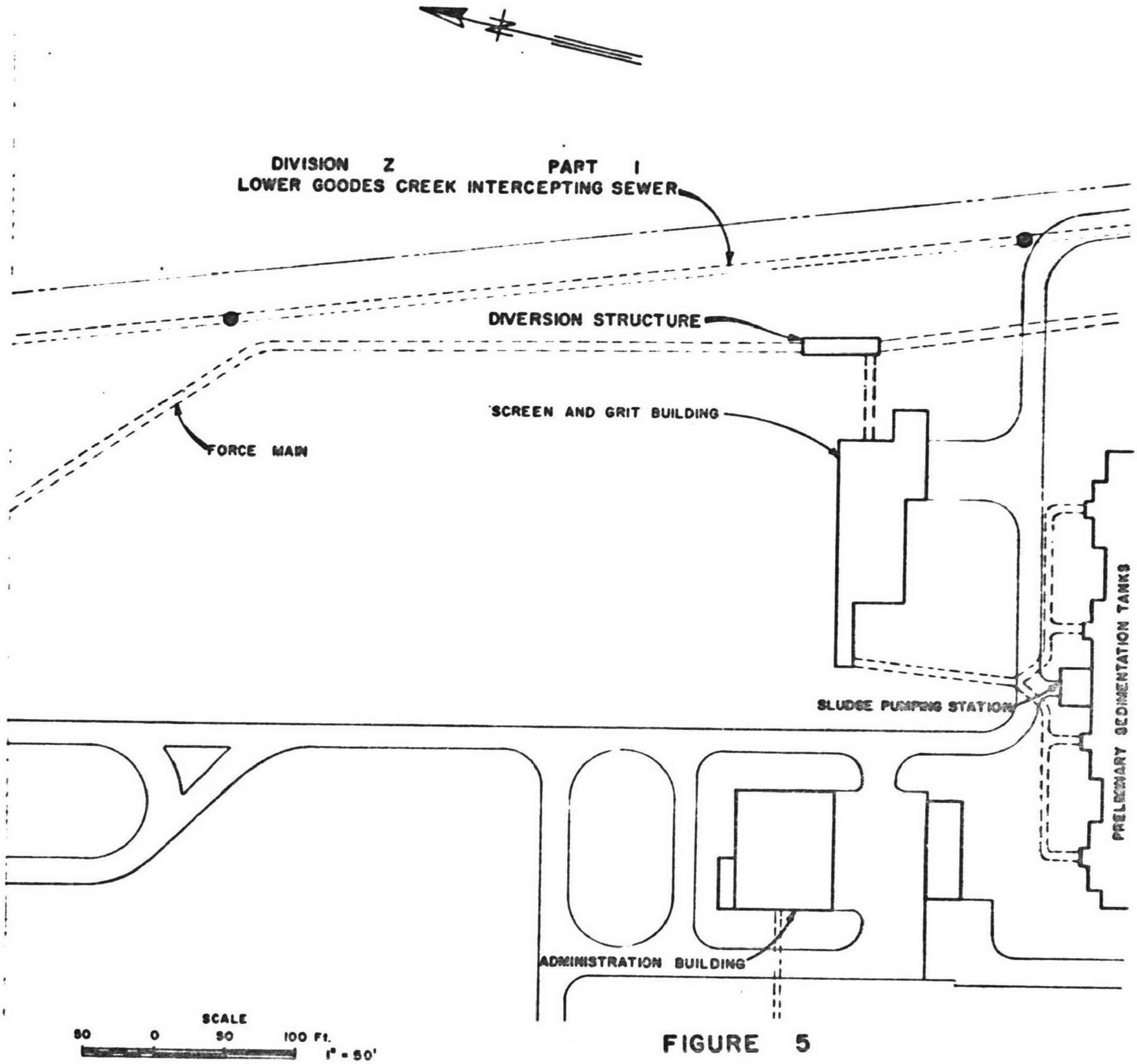


FIGURE 5

EXISTING CONDITIONS PRIOR TO
CONSTRUCTION OF
GRIT REMOVAL FACILITIES

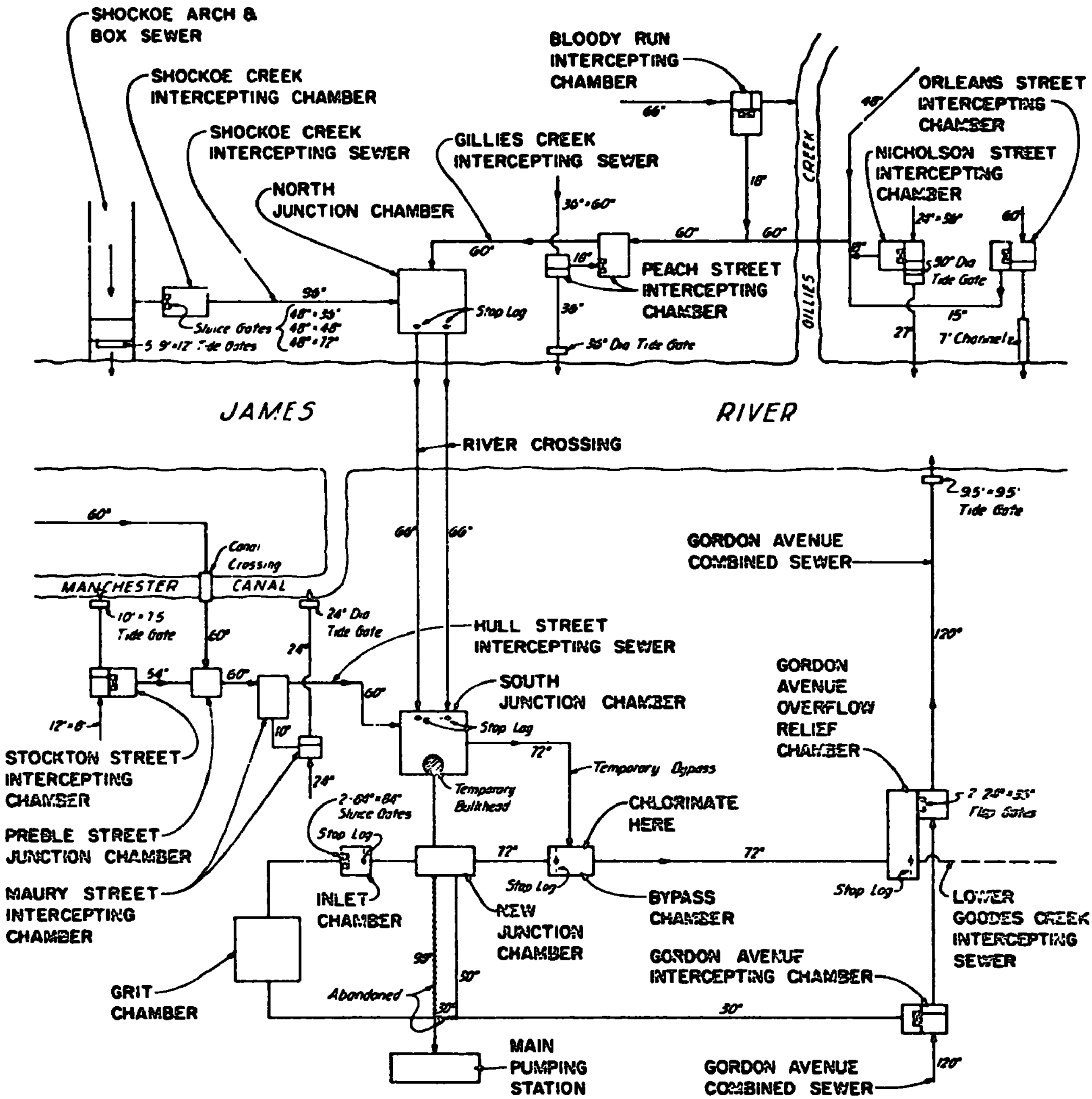


FIGURE 6
FLOW DIAGRAM
TEMPORARY BYPASSING WITH CHLORINATION

chamber was connected to the plant.

2. Alternate B visualized the construction of a Supplemental Pumping Station. Sewage could be diverted to the Supplemental Pumping Station by reversing the flow through the 72-inch Lower Goodes Creek Intercepting Sewer which ultimately would carry sewage to a junction chamber adjacent to the Main Pumping Station, and thereby divert the sewage around the main pumping station and force main to the treatment facilities. A temporary bulkhead would be required to be installed at the outlet of the south junction chamber and in the diversion chamber where the new supplemental pumps would discharge. This would permit the new grit removal chamber to be connected and the cleaning and maintenance of the Main Pumping Station and force main to take place without the necessity of bypassing untreated sewage into the James River.

   A Supplemental Pumping Station could solve the immediate problem, and could be used in the future should an emergency arise requiring a shutdown of the Main Pumping Station and force main.

   The arrangement for a Supplemental Pumping Station and ancillary facilities is shown on Figure 7.

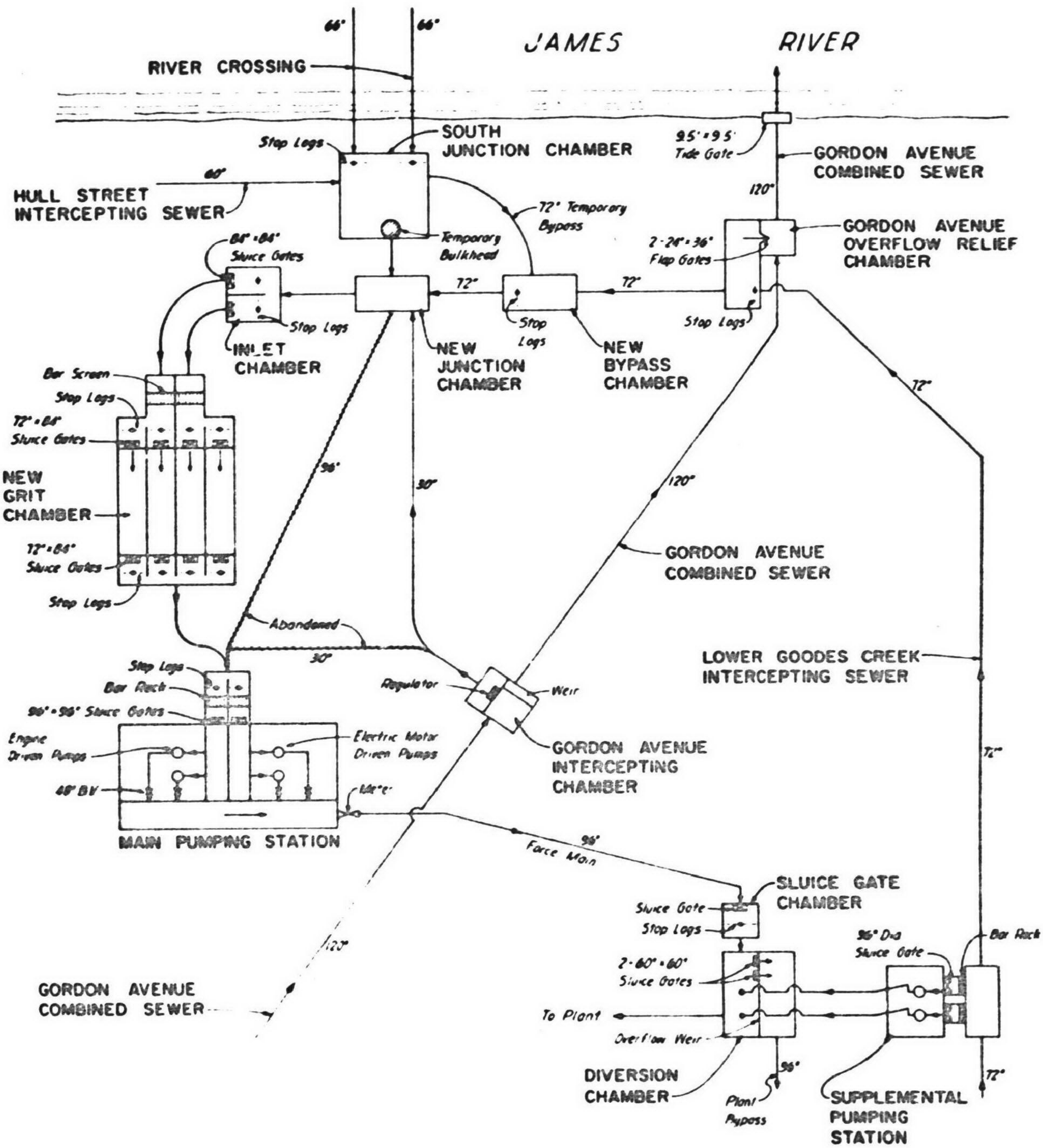


FIGURE 7
FLOW DIAGRAM
ALT. B WITH SUPPLEMENTAL PUMPING STA.

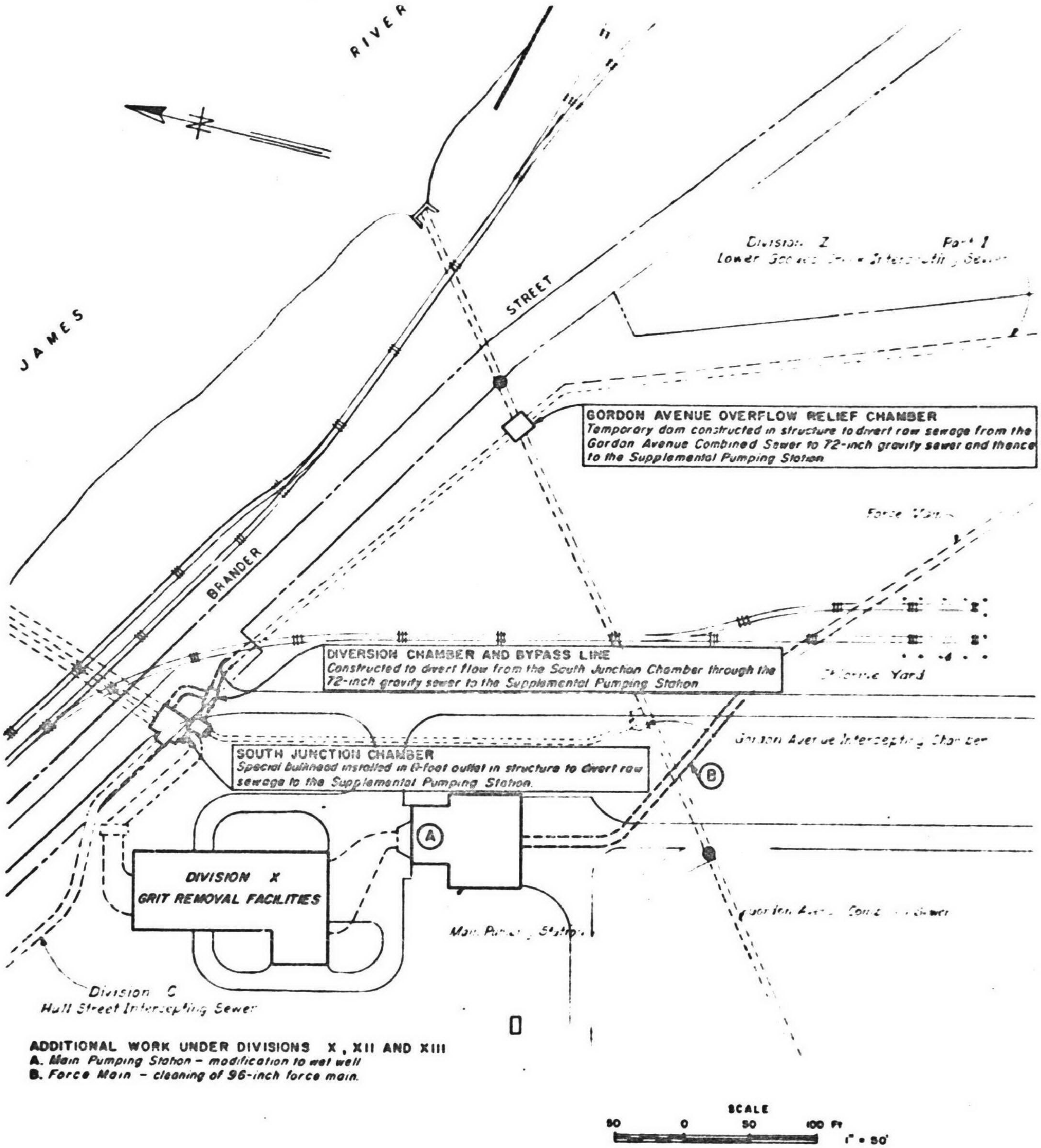
C. Physical Requirements for Constructing Supplemental Pumping Station

1. Location of Supplemental Pumping Station

The preferred location of the Supplemental Pumping Station on the Lower Goodes Creek Intercepting Sewer was such that the pumping station would not be excessively deep, the water levels in the wet well would not be too high so as to surcharge the sewers and cause overflow into the James River, and that relatively inexpensive modifications would be required to the existing structures.

As shown on Figure 8, a suitable location for the Supplemental Pumping Station would be close to the existing 96-inch force main. Figure 9 shows the hydraulic profiles extending from the river crossing through the Lower Goodes Creek Intercepting Sewer, through the Supplemental Pumping Station and to the diversion structure. The profile also shows the connection from the south junction chamber through the new Grit Chamber to the Main Pumping Station. The flow from the pumping station would be discharged to the existing diversion chamber at which point pre-chlorination normally occurs.

The location had to be such that at any time in the future should it become necessary to provide additional pumping capacity at the Main Pumping Station


JAMES RIVER
BRANDER STREET
GORDON AVENUE OVERFLOW RELIEF CHAMBER
Temporary dam constructed in structure to divert raw sewage from the Gordon Avenue Combined Sewer to 72-inch gravity sewer and thence to the Supplemental Pumping Station
DIVERSION CHAMBER AND BYPASS LINE
Constructed to divert flow from the South Junction Chamber through the 72-inch gravity sewer to the Supplemental Pumping Station
SOUTH JUNCTION CHAMBER
Special bulkhead installed in 8-foot outlet in structure to divert raw sewage to the Supplemental Pumping Station.
A
B
DIVISION X
GRIT REMOVAL FACILITIES
Division C
Hull Street Intercepting Sewer
ADDITIONAL WORK UNDER DIVISIONS X, XII AND XIII
A. Main Pumping Station – modification to wet well
B. Force Main – cleaning of 96-inch force main.
SCALE
50 0 50 100 Ft
1" = 50'

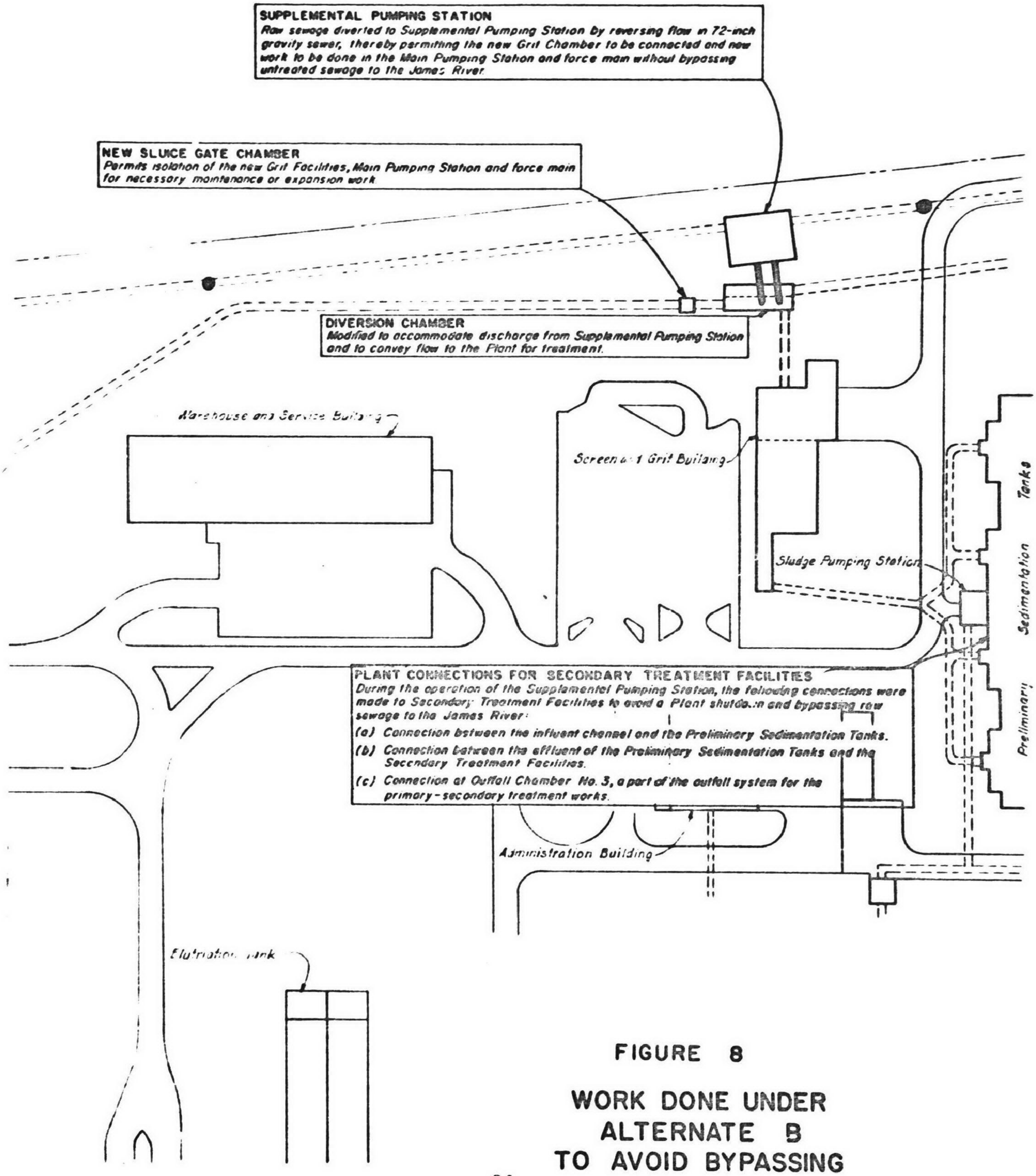
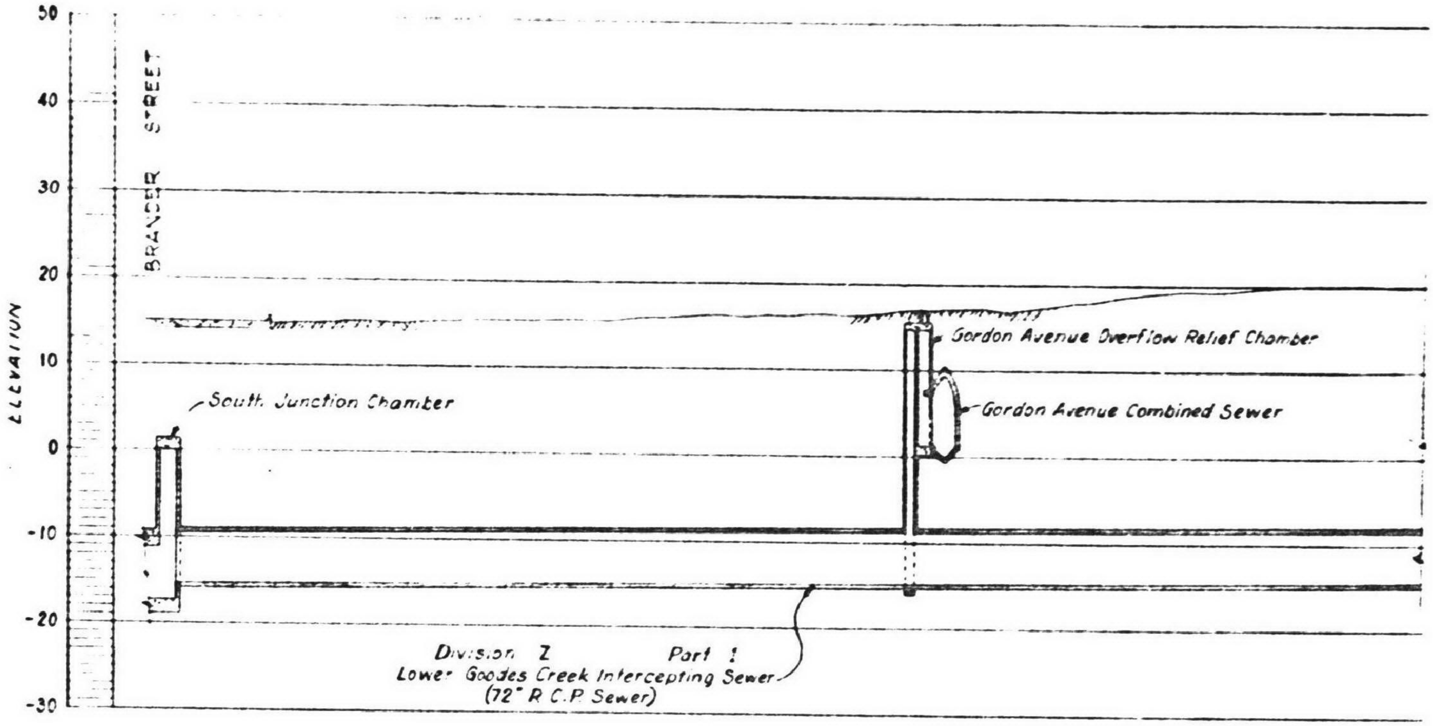


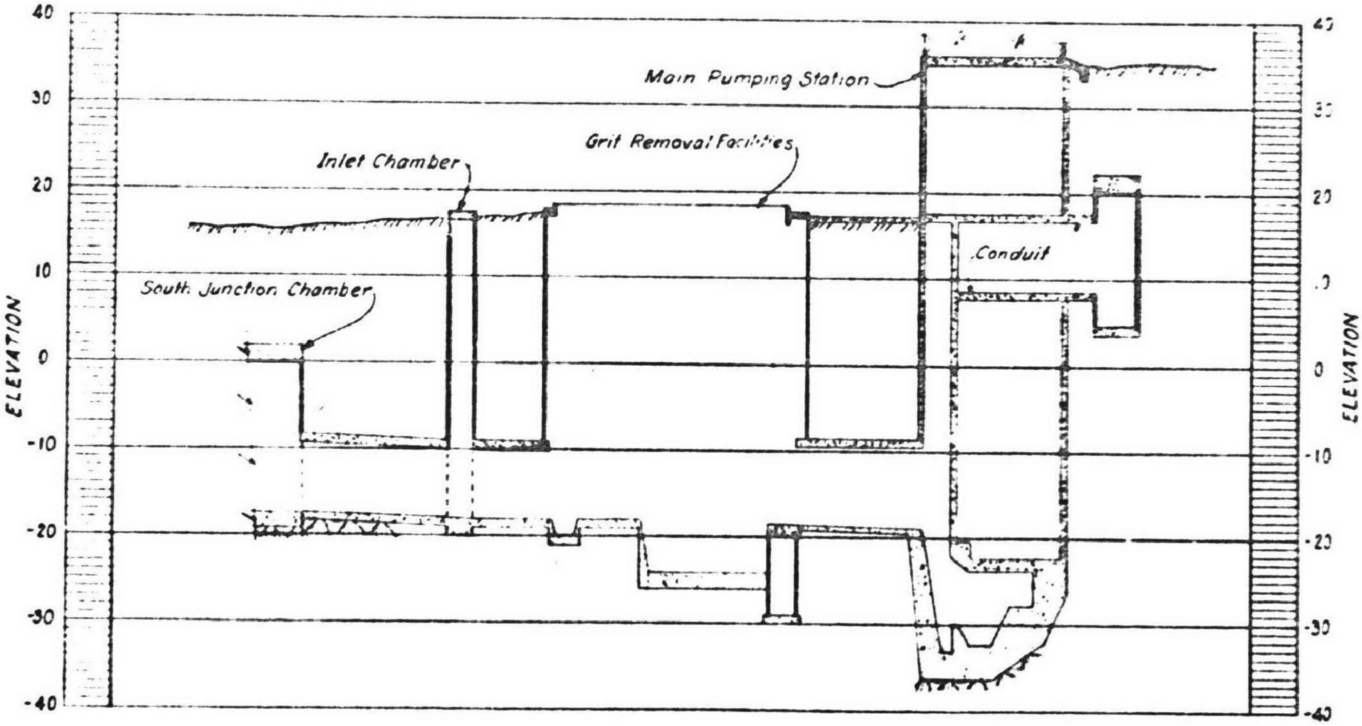
FIGURE 8

WORK DONE UNDER
ALTERNATE B
TO AVOID BYPASSING



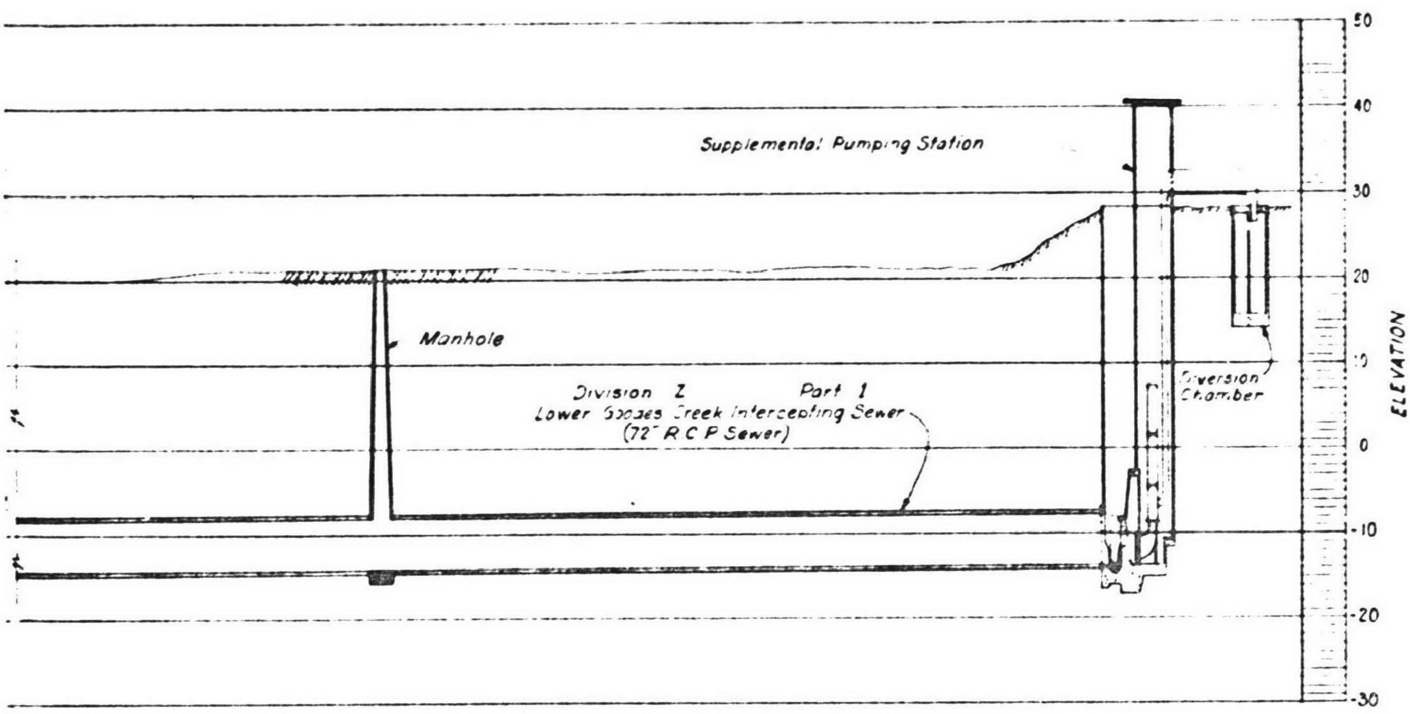
PROFILE

FROM SOUTH JUNCTION CHAMBER TO DIVERSION CHAMBER



PROFILE

FROM SOUTH JUNCTION CHAMBER TO MAIN PUMPING STATION



PROFILE

FROM SOUTH JUNCTION CHAMBER TO DIVERSION CHAMBER

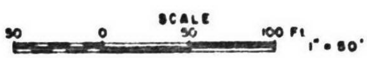


FIGURE 9

HYDRAULIC PROFILES

or make any repairs to equipment, all of which would require a shutdown, the Supplemental Pumping Station could be reactivated thereby permitting continuous operations without bypassing to the James River.

2. Gordon Avenue Overflow Relief Chamber

Prior to the directive from the Federal Water Pollution Control Agency to accomplish the plant improvements without bypassing, the Gordon Avenue Overflow Relief Chamber was designed to take the flow from the Lower Goodes Creek Intercepting Sewer and also to serve as the point of chlorination of all the sewage being bypassed to the James River. With the construction of the Supplemental Pumping Station, this structure no longer serves any purpose.

3. Plant Connections for Secondary Treatment Facilities

Connections of the secondary treatment facilities which were originally planned to be made during the 110 days of plant shutdown were redesigned, based on the new concept of the Federal Water Pollution Control Administration that no bypassing to the river is permitted. The three connections which were made while the plant was kept in operation are as follows:

(a) Connection between the influent channel and the preliminary sedimentation tanks.

(b) Connection between the effluent of the preliminary sedimentation tanks and the secondary treatment facilities.

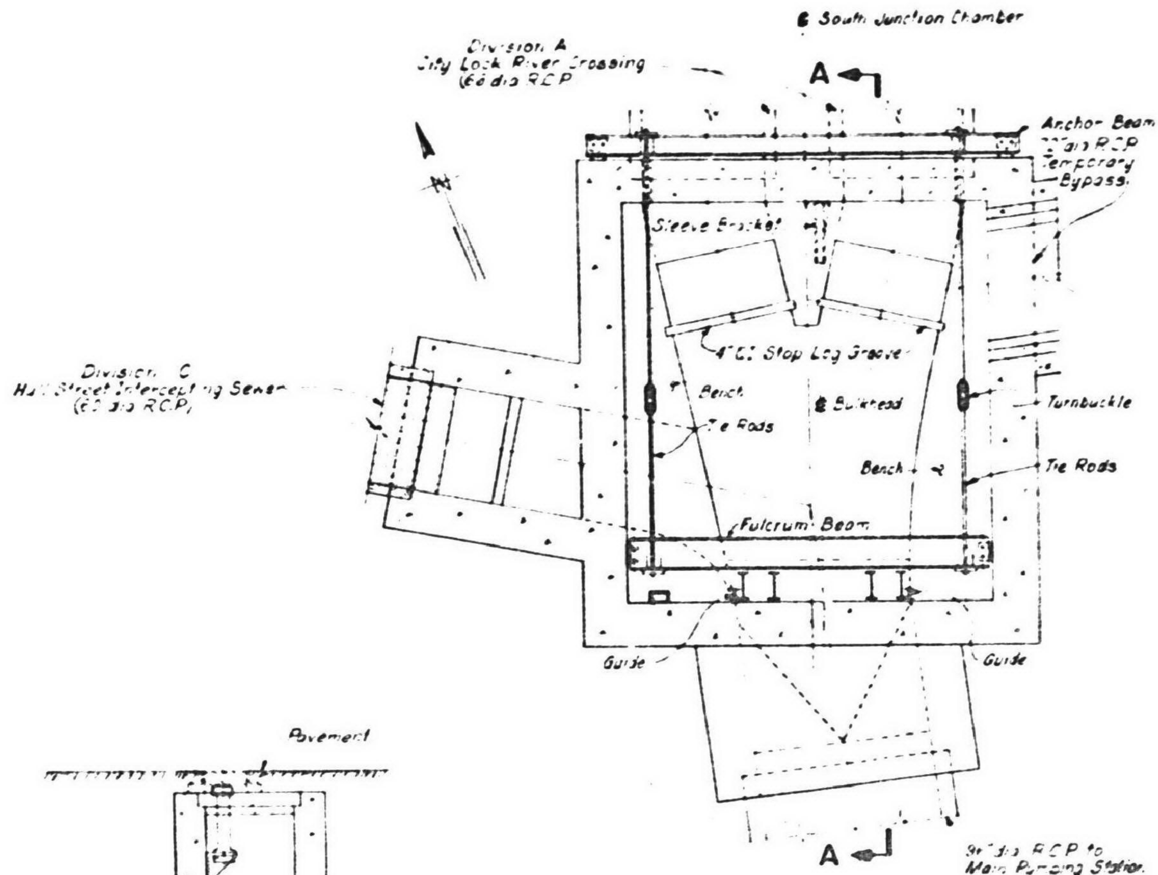
(c) Connection at Outfall Chamber No. 3, which is part of the outfall system for the primary-secondary treatment works.

4. Bulkheading the Inlet to the Main Pumping Station

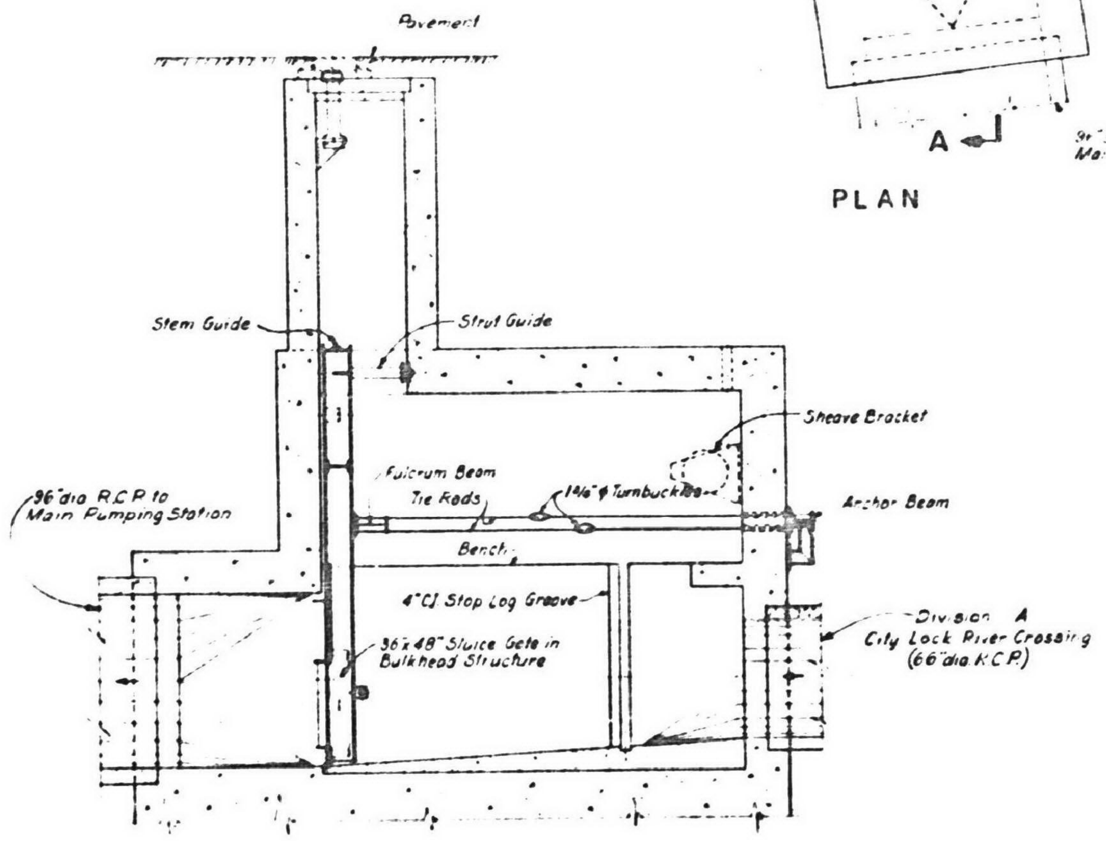
Figure 10 shows the existing south junction chamber and the temporary bulkhead which must be installed in the 8-foot square outlet. This bulkhead must be installed in this junction chamber to divert the flow to the Supplemental Pumping Station. A 3-foot by 4-foot sluice gate was installed on the bulkhead to permit its installation.

D. The Design Problem

The average tributary dry weather flow to the Wastewater Treatment Plant is approximately 30 mgd with minimum flows in the range of 15 to 17 mgd and maximum dry weather flows approximating 50 mgd. In the design of the Supplemental Pumping Station, it was planned to provide two or three pumping units with an installed capacity ranging between 90 and 100 mgd. Therefore, operating these units simultaneously, capacity would be available for approximately three times the average



PLAN



SECTION A-A

A SUGGESTED SEQUENCE OF WORK TO BE PERFORMED

INSTALLATION OF BULKHEAD STRUCTURE

1 Install two bulkhead guide units bolted to the south wall of the chamber and located at El -1 0' but omitting the guide plates

2 Install the tieback sheave bolted to the north wall of the chamber and located at El -4' 0" and the geared hoist mounted on the chamber roof at El + 2 0"

3 Lower the horizontal fulcrum beam into the chamber and let it rest temporarily on the concrete bench at El -8 - 0'

4 Lower the bulkhead structure assembly (with sluice gate in open position bolted in place and the tieback sling attached) guiding it carefully and flexing the side neoprene seal strips northward until the bottom of the bulkhead is within 3 3 of the invert of the chamber and the face of the vertical bulkhead beam flanges is 9 from the face of the south wall

5 Install guide plates on two bulkhead guide units and connect the tieback sling to geared hoist cable passing under the sheave mounted on the north wall Tighten the tieback cable Now the entire bulkhead structure is in fully guided control and is ready for the lowering in place operation

6 Lower the bulkhead structure assembly guiding it carefully while maintaining a 9" clearance between the vertical bulkhead beam flanges and the face of the wall until the bottom of the bulkhead is within 1 of the invert of the chamber This operation requires a carefully coordinated release of both hoisting cables in order to maintain an essentially vertical position of the bulkhead structure Uninterrupted flow of sewage through the chamber will begin to exert a constantly increasing pressure on the bulkhead structure and will be resisted by the pull on the tieback cable The impeded flow will cause sewage level to rise and may eventually submerge the open sluice gate port However it is not expected to rise above approximately El -9 0 or approximately one foot below the chamber bench elevation The bulkhead structure is now ready for the lateral seating operation

7 Release gradually the tieback cable and permit water pressure to move the bulkhead structure southward while still maintaining its essentially vertical position and being certain that the side neoprene seal strips are properly flexed northward When 1 clearance between the vertical bulkhead beam flanges and the face of the wall is attained lower the bulkhead structure the remaining distance of 1" permitting it to rest on the invert of the chamber Disconnect the main hoist cable Install four horizontal beam struts located at El +1 0' Bring bulkhead structure to its final vertical alignment by adjusting 4 sets of four jacking set screws located on the strut plates at El +1 0 and 4 sets of two set screws located on the vertical beam flanges adjacent to the south wall of the chamber at El -8 1½' Install shelf angles under the top channel of the bulkhead structure at El + 2 0' Loosen the geared hoist cable

8 Install horizontal fulcrum beam on shelf angles mounted on the east and west walls of the chamber at El -8' 1½ and bolt it to four vertical beams of the bulkhead structure Install anchor beam located outside the north wall of the chamber Install 4 1½ dia tie rods with turnbuckles tying the fulcrum beam to the outside anchor beam Tighten the tie rods until all four sets of two set screws located on the vertical beam flanges at El -8 1½' are relieved of their initial load Caulk tight the annular space between the tie rods and the holes in the north wall of the chamber

9 Caulk tight the open space between the bulkhead structure and the adjacent concrete wall and bench at El -8 0

10 Install sluice gate extension stem stem guide and the operating floor stand together with its cast iron mounting bracket anchored to wall at El + 12 - 0"

11 Close the sluice gate Sewage level will rise in the chamber sufficiently high to accommodate the flow through the previously provided bypass connection located in the east wall of the chamber It is not expected to rise above approximately El 0 0

REMOVAL OF BULKHEAD STRUCTURE

Essentially this shall follow the steps of the installation procedure except in reverse order

1 Open the sluice gate Sewage level will drop below the bench level at El -8' - 0"

2 Remove sluice gate operating floor stand cast iron mounting bracket stem guide and the extension stem Remove shelf angles located under the top channel of the bulkhead structure at El + 2 0

3 Remove tie rods and the outside anchor beam and supporting brackets Remove fulcrum with supporting shelf angles and lay it temporarily aside on the bench at El -8 0

4 Tighten the geared hoist cable Remove four horizontal beam struts located at El + 1 Connect the main hoist cable and tighten it Raise the bulkhead structure 1" off its seating level

5 Tighten gradually the tieback cable and move the bulkhead structure northward until a 9" clearance is obtained between the vertical bulkhead beam flanges and the face of the wall

6 Raise the bulkhead structure until the bottom of the bulkhead is 3 3" above the invert of the chamber This shall be done by a carefully coordinated take-up of both hoisting cables Remove guide plates from the bulkhead guide units located at El - 1 0' Disconnect the tieback sling

7 Raise the bulkhead structure assembly out of the chamber Remove the bulkhead guide units located at El - 1' 0'

8 Remove the fulcrum beam and the supporting shelf angles which have been temporarily set aside on the bench at El -8 0'

9 Remove the tieback sheave bolted to the north wall and the geared hoist mounted on the chamber roof at El + 2' 0"

FIGURE 10

SOUTH JUNCTION CHAMBER
TEMPORARY BULKHEAD

dry weather flow or twice the maximum dry weather flow.

In addition,the outlet from each pump was designed with a siphon to prevent backflow from the point of discharge (existing diversion chamber) while the Main Pumping Station is in operation and the Supplemental Pumping Station is in a standby condition.

In considering the above,it was important to find equipment which was readily available and easily installed.

The various motive powers considered to drive the pumps were gas engines, diesel engines and electric motors.

Sludge gas or natural gas were not available at the plant site during the time of design or construction. Therefore, gas engine drives were not considered.

Diesel engines would be required to operate for extended periods of time at very slow speeds due to the minimum sewage flows which could be encountered at the pumping station. This type of operation, with economical high speed engines, would require excessive maintenance to keep the injectors and the ports clean; thus the reliability of the station would be reduced. Therefore, diesel engine drives were not used.

Electric motors require a minimum amount of maintenance with very good reliability. In addition, reliable power was available a short distance from the

Supplemental Pumping Station. Therefore, variable speed electric motors were selected as the pump drives.

The control of the pump speed is important so that the wet well will not rise to such a level that the sewers surcharge and discharge raw sewage into the James River. The depth of the pumping station was set so that the pumps would not operate dry at minimum speed when the level in the wet well was at a minimum.

The bulkhead required to be installed in the existing south junction chamber presented a difficult problem. Although this was the best possible location for the bulkhead, no standard device would work, including inflatable plugs, flat plates, stop logs, etc. Whatever type of bulkhead was to be used would require installation while the sewage was flowing through the existing structure. The structure, however, was not designed for the head which would be imposed on it with the installation of a bulkhead.

An involved and costly procedure was necessary to solve this problem.

SECTION IV

THE CONSTRUCTION DESIGN

A. Description of the Pumping Station Design

1. Structural: The supplemental pumping station was to be designed as a simple economical structure consisting of a sheet steel piling cofferdam to be built around the existing 72-inch ID Lower Goodes Creek Intercepting Sewer and to act as the substructure for the pumping station. A dividing wall of sheet steel piling set on a short concrete wall divides the substructure into the wet well and the pump room in the dry well. The scheme of sheeting was with wales and cross-lot bracing located in such a manner as to form a structurally sound substructure and to permit reasonable location of the required equipment. The design was such that the sheeting was to be driven to rock and then the concrete base placed and keyed into the rock.

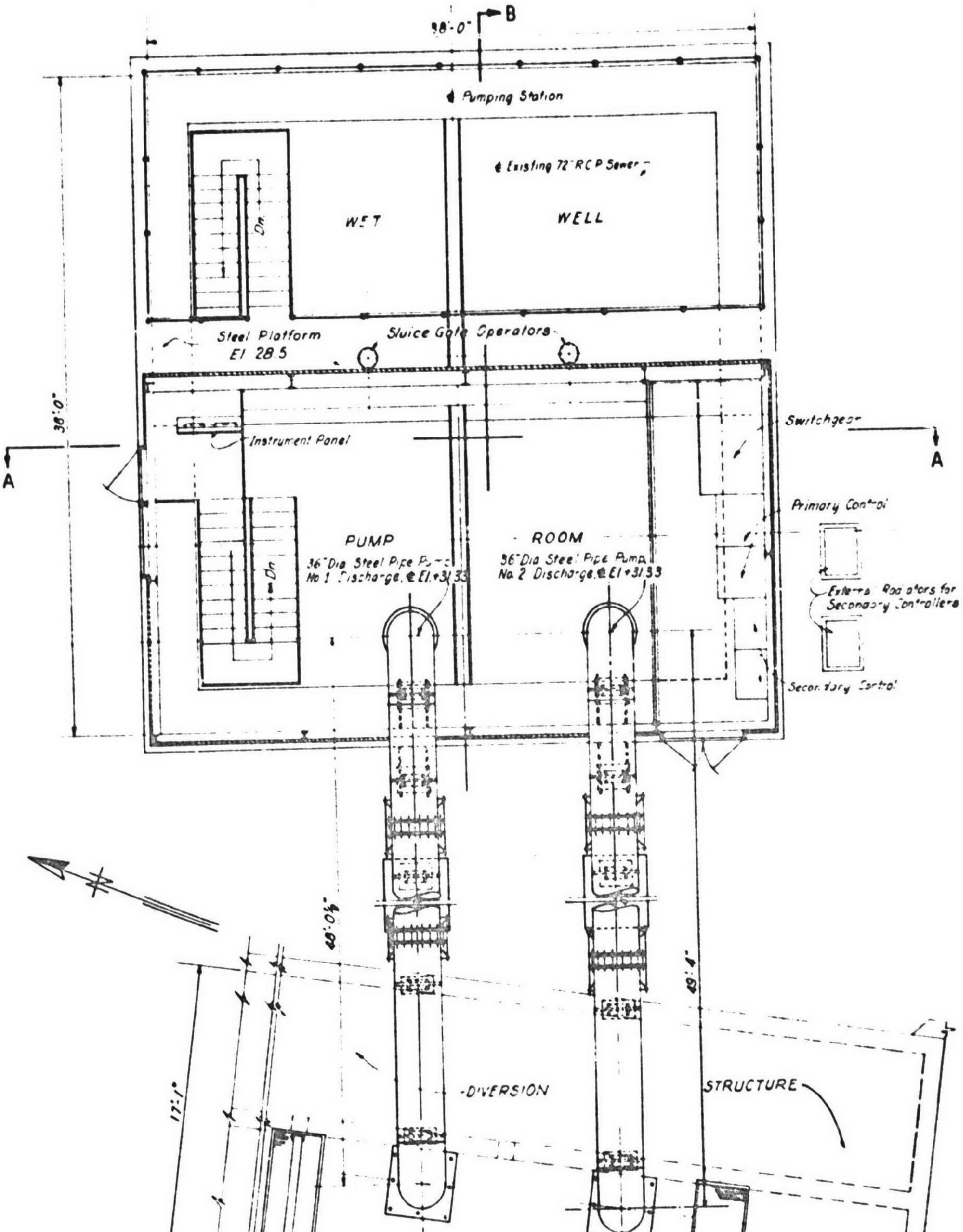
The loads for a structure as deep as this were very substantial necessitating very large walers and struts. After the structure was completed, the upper portion of the existing 72-inch reinforced concrete Lower Goodes Creek Intercepting Sewer pipe was removed, thus forming part of the wet well. Figures 11 and 12 illustrate the type of construction.

Figures 13 to 23, inclusive, illustrate a general sequence of construction of the Supplemental Pumping Station and the modifications to the diversion structure.

2. Architectural: A superstructure of economical materials was constructed over the pump room in the dry well (See Figure 12), and constructed of a structural steel frame with insulated metal siding. The siding was made up of an exterior steel panel with a paint finish and an interior steel panel with a baked-on finish and 1-1/2 inch thick fiber glass insulation between the panels. Hollow metal doors and frames and aluminum louvers were provided in the walls.

The roof was constructed of four sections made up of 1-1/2 inch deep, formed steel decking. The outer two sections were spot welded to the steel roof framing and the inner two sections were bolted to the steel framework to provide for the removal of the pumping units. A vapor barrier, 1-1/2 inches of rigid insulation, a four-ply tar and gravel roofing was applied over the metal deck. A metal facia and water dam was installed around the perimeter of the roof. Sheet metal downspouts were provided. Steel stairs were provided for access to the pump room floor.

The wet well was not covered, but was protected with a railing around the entire perimeter. Aluminum stairs were provided in the wet well for access to the bar racks.



PLAN AT EL+28.5

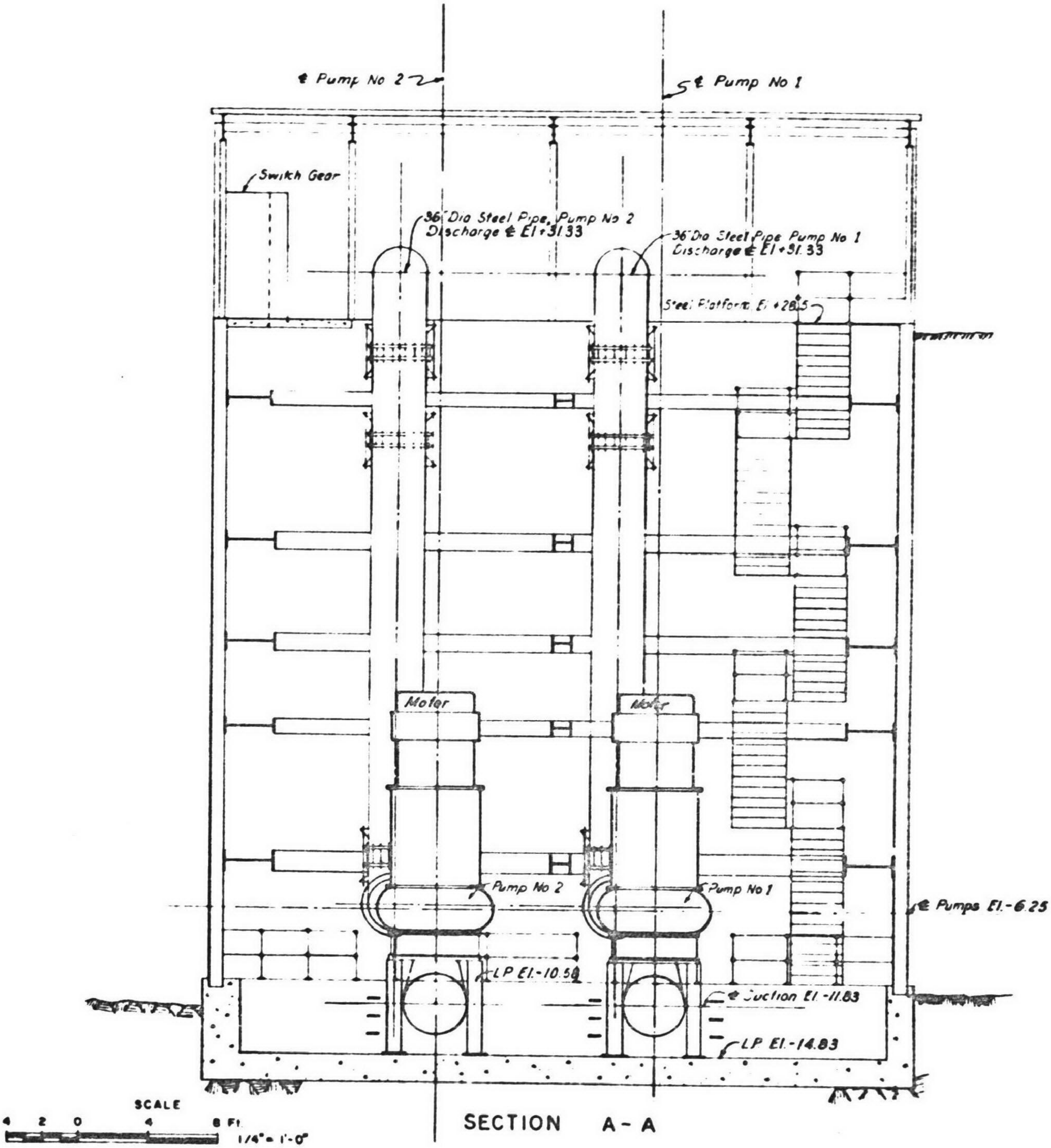
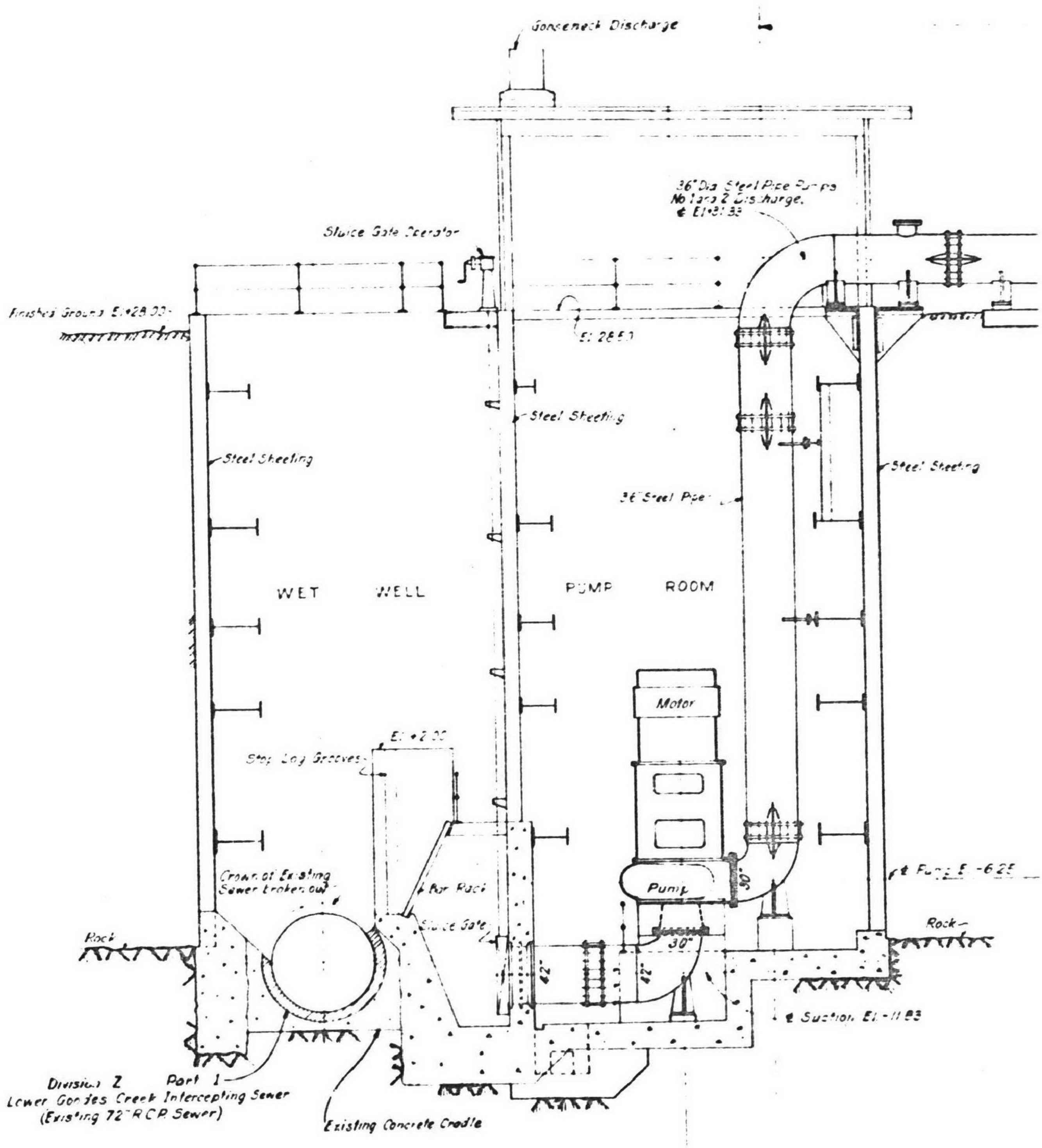
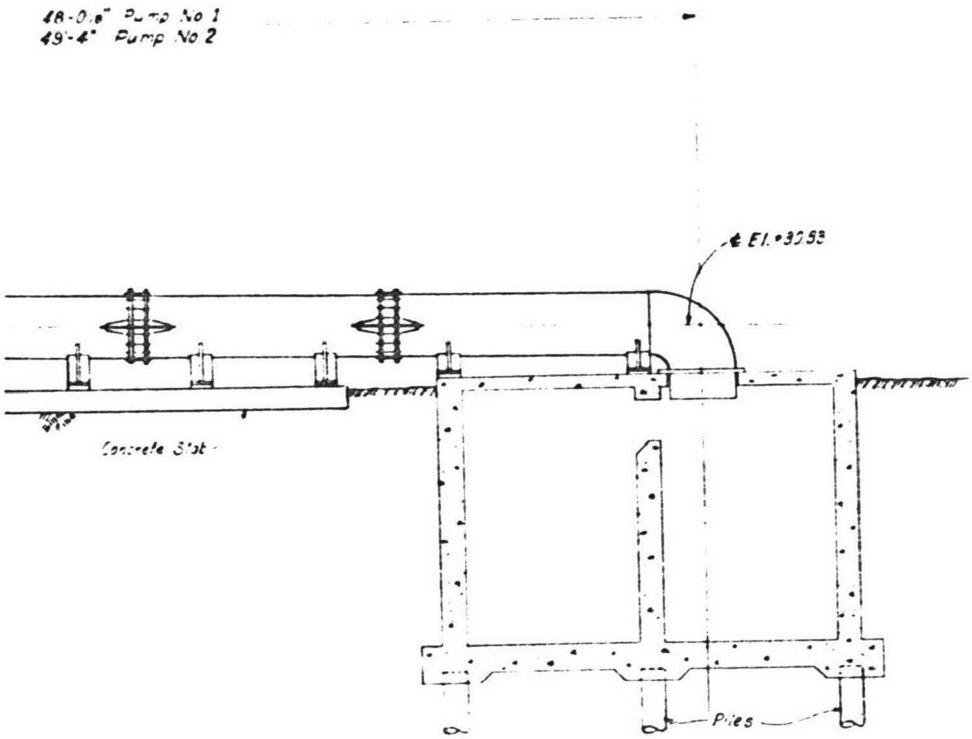


FIGURE 11

PLAN AND SECTION


Gooseneck Discharge
36" Dia Steel Pipe Pumps No 1 and 2 Discharge, ℄ El+31.33
Sluice Gate Operator
Finished Ground El+28.00
El 28.50
Steel Sheeting
Steel Sheeting
Steel Sheeting
36" Steel Pipe
WET WELL
PUMP ROOM
Motor
El +2.00
Stop Log Grooves
Crown of Existing Sewer broken out
Bar Rack
Pump
90°
Sluice Gate
30°
42"
42"
Rock
Rock
℄ Pump El -6.25
℄ Suction El -11.83
Division 2 Part 1
Lower Gordes Creek Intercepting Sewer
(Existing 72" R.C.P. Sewer)
Existing Concrete Cradle

SECTION



EXISTING
DIVERSION CHAMBER

SCALE
4 2 0 4 8 Ft.
1/4" = 1'-0"

B-B

FIGURE 12

SECTION

Figure 13
Supplemental Pumping Station
Grading for Site

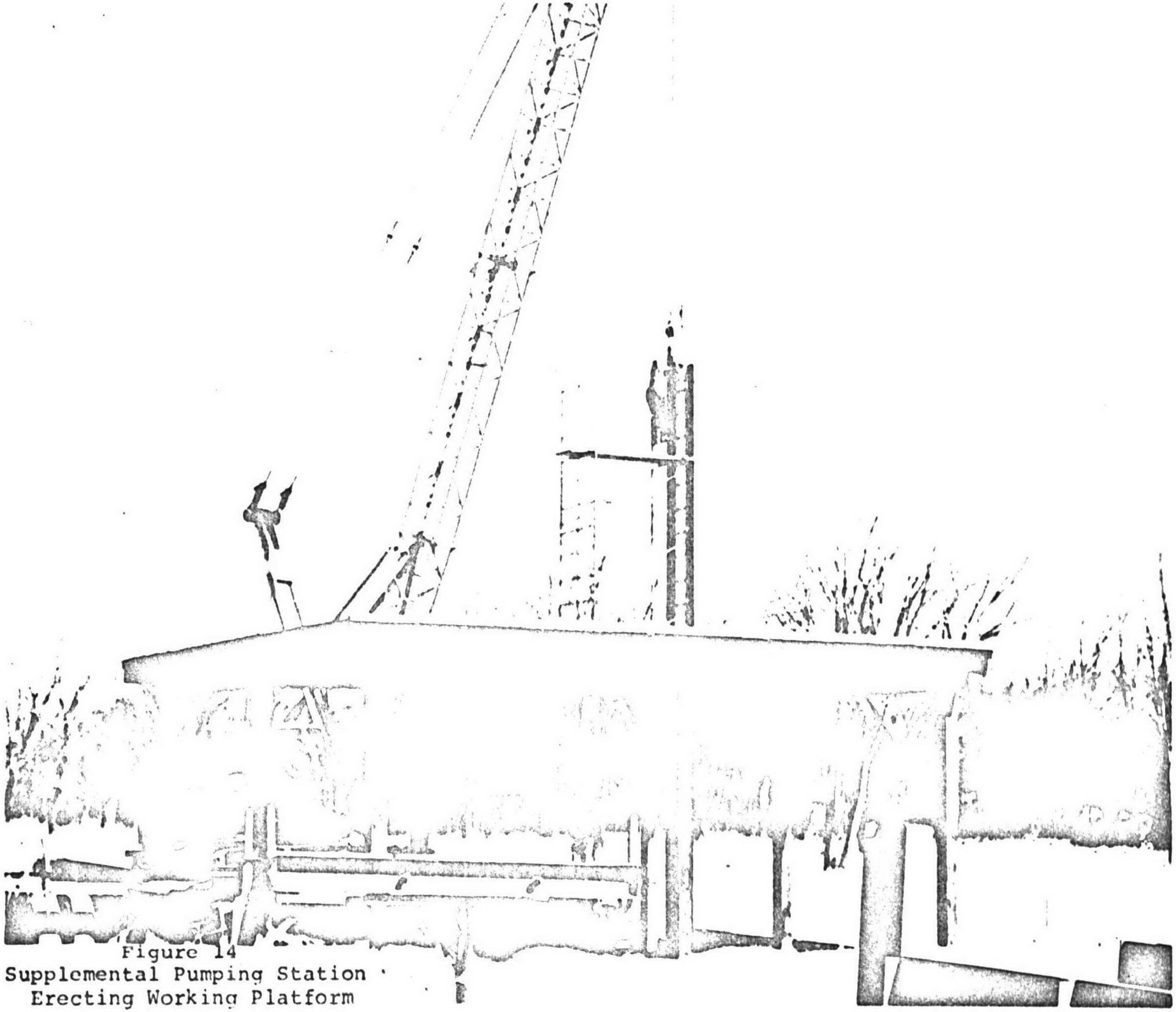


Figure 14
Supplemental Pumping Station
Erecting Working Platform

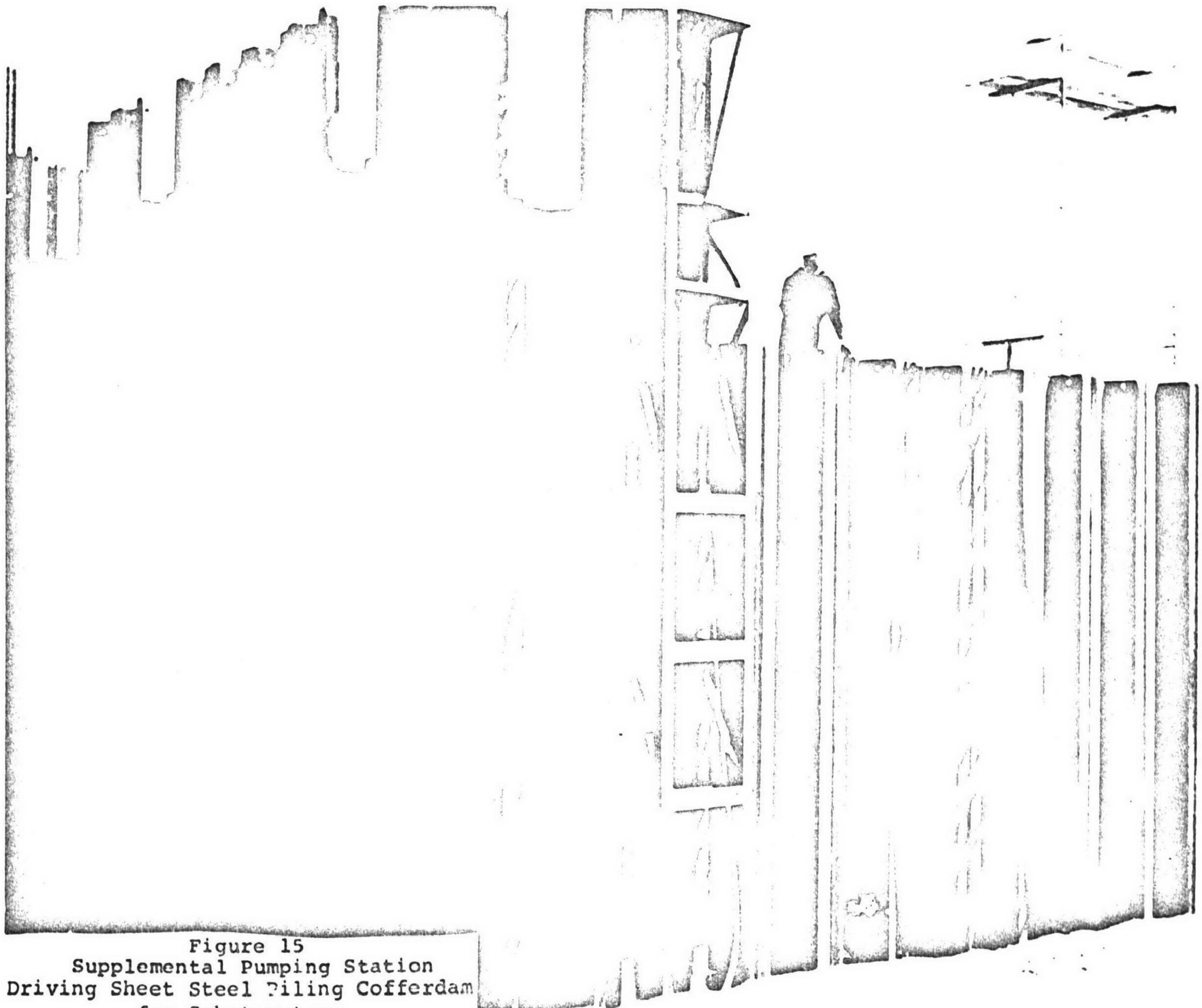


Figure 15
Supplemental Pumping Station
Driving Sheet Steel Piling Cofferdam
for Substructure

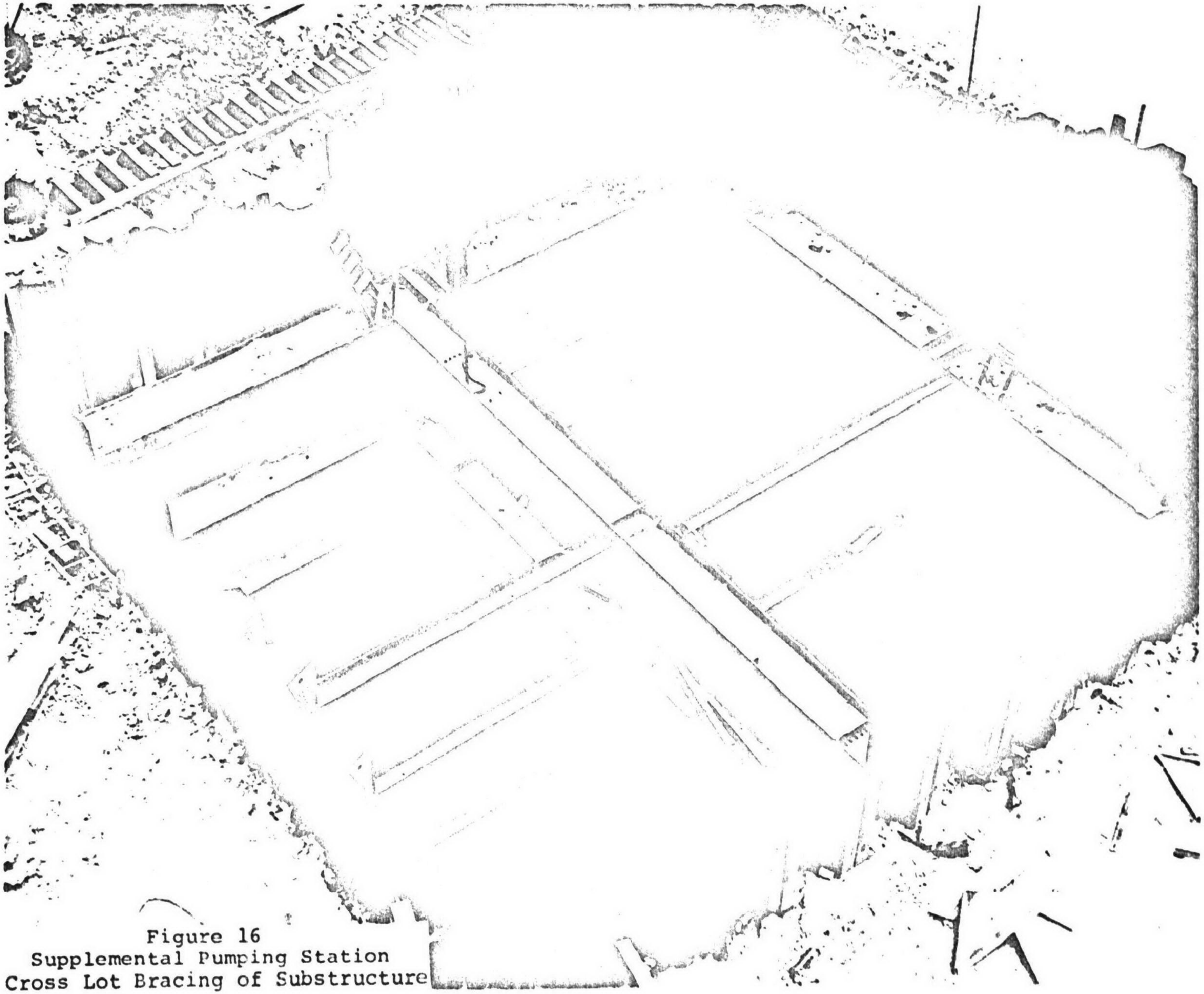


Figure 16
Supplemental Pumping Station
Cross Lot Bracing of Substructure

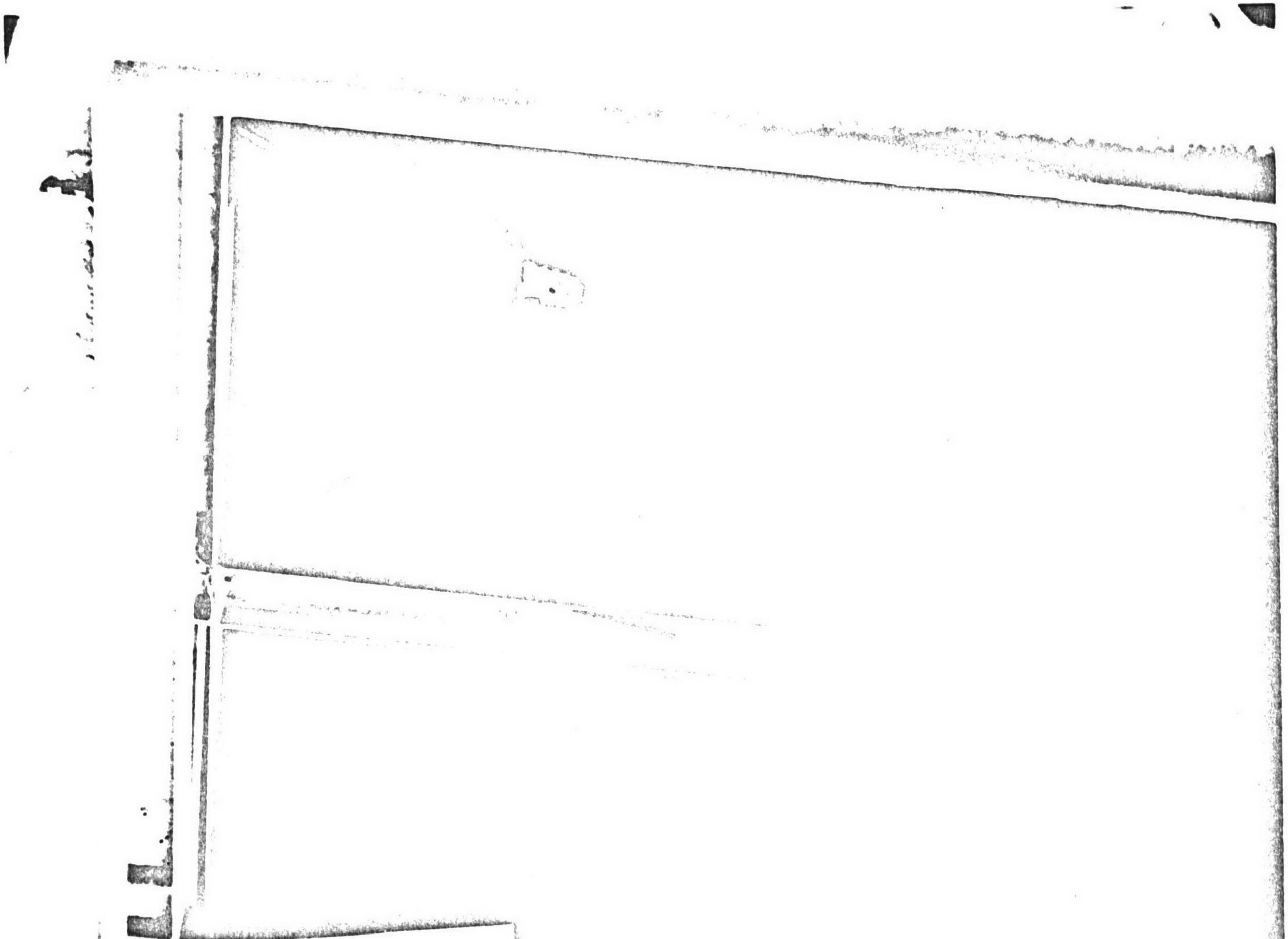


Figure 17
Supplemental Pumping Station
Existing 72-Inch
Lower Goodes Creek Intercepting Sewer

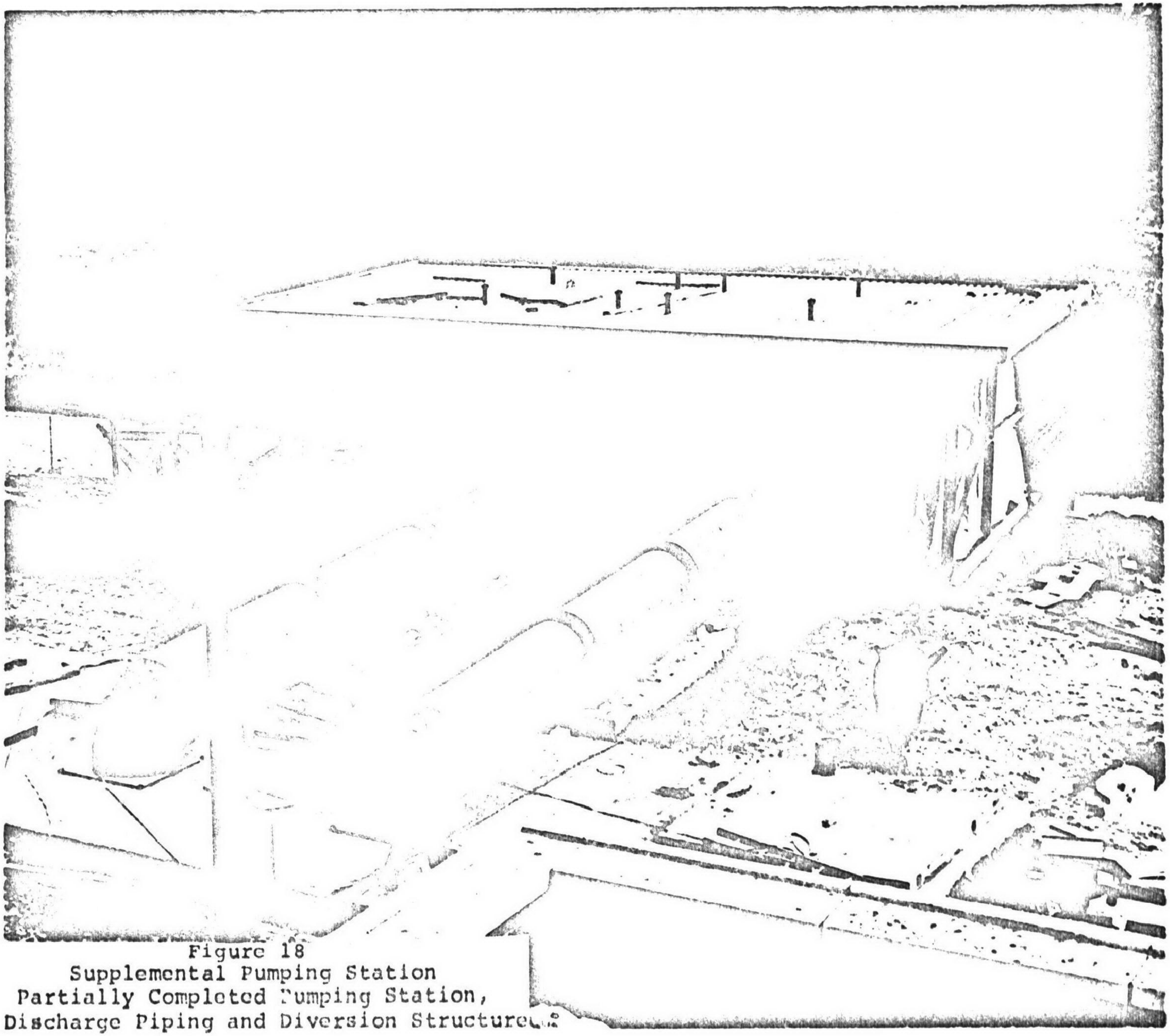


Figure 18
Supplemental Pumping Station
Partially Completed Pumping Station,
Discharge Piping and Diversion Structures

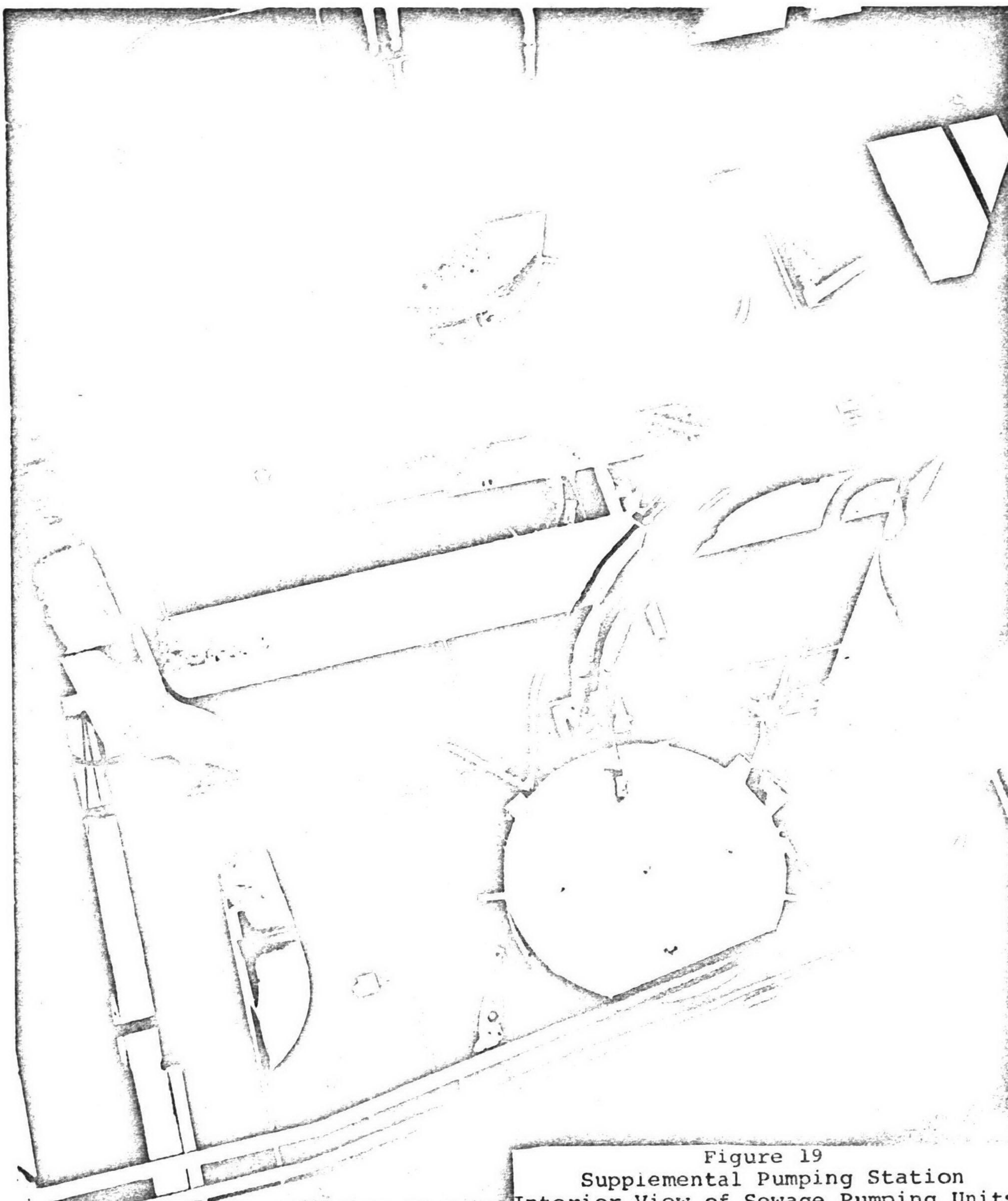


Figure 19
Supplemental Pumping Station
Interior View of Sewage Pumping Units

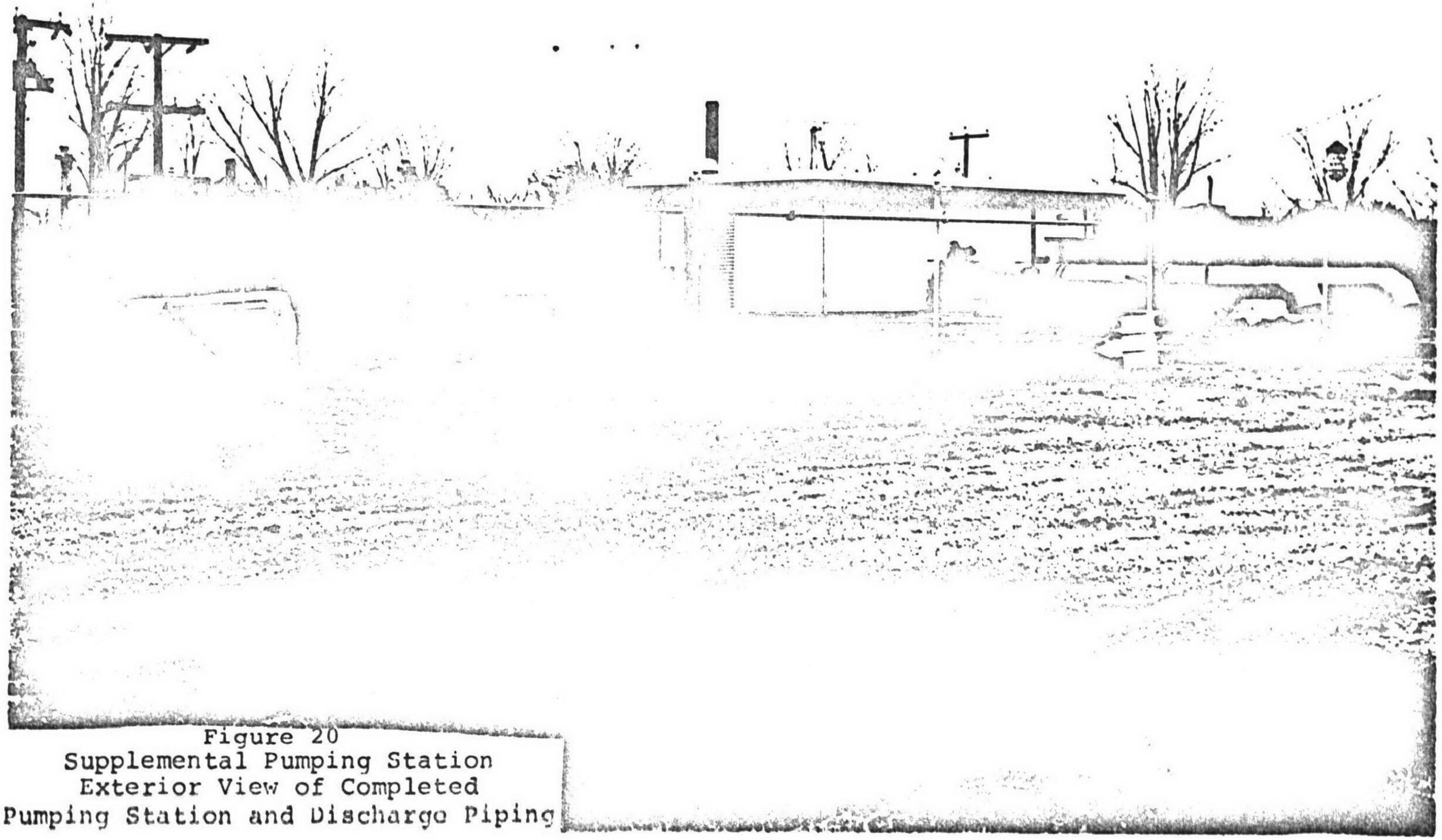


Figure 20
Supplemental Pumping Station
Exterior View of Completed
Pumping Station and Discharge Piping

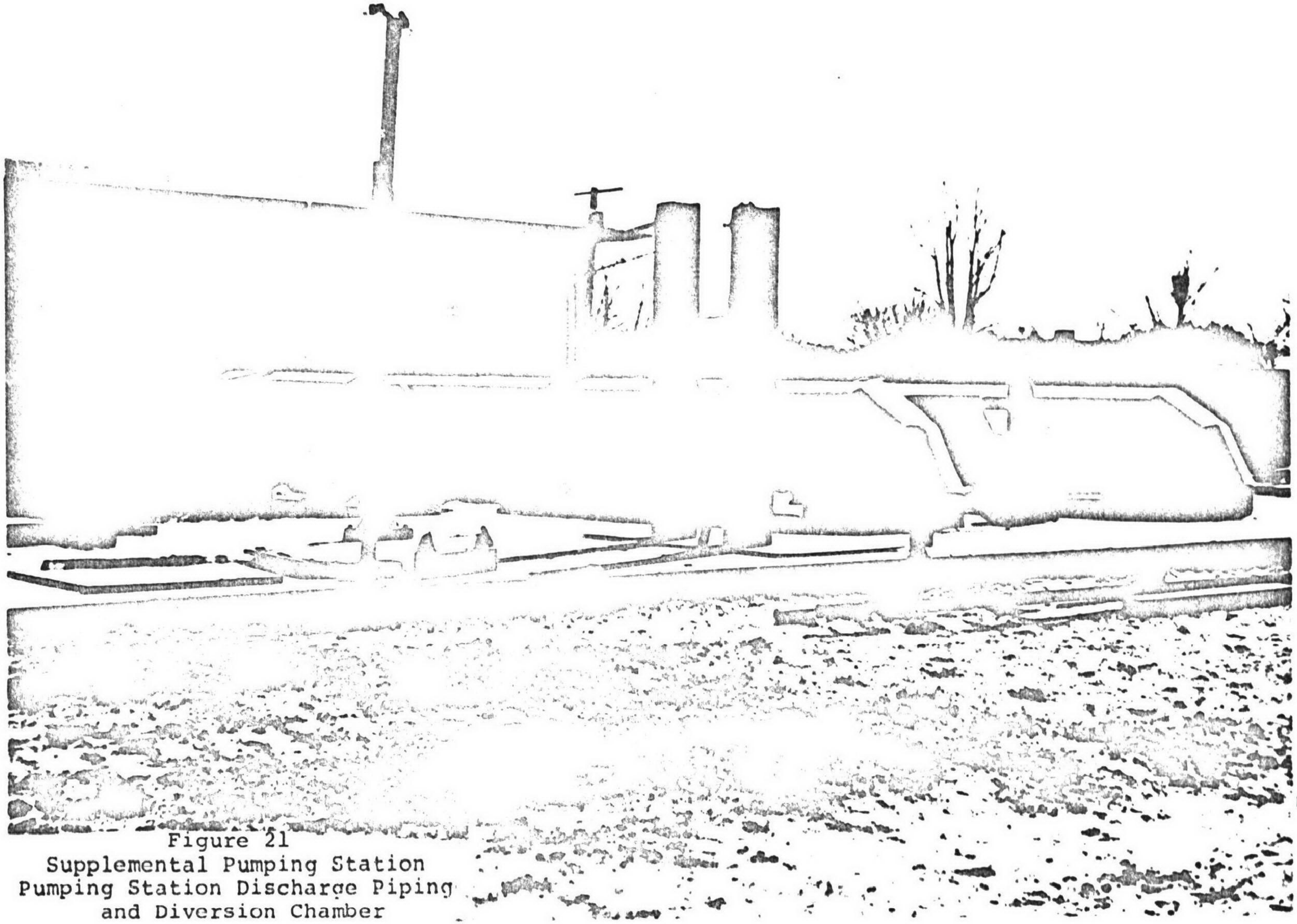


Figure 21
Supplemental Pumping Station
Pumping Station Discharge Piping
and Diversion Chamber

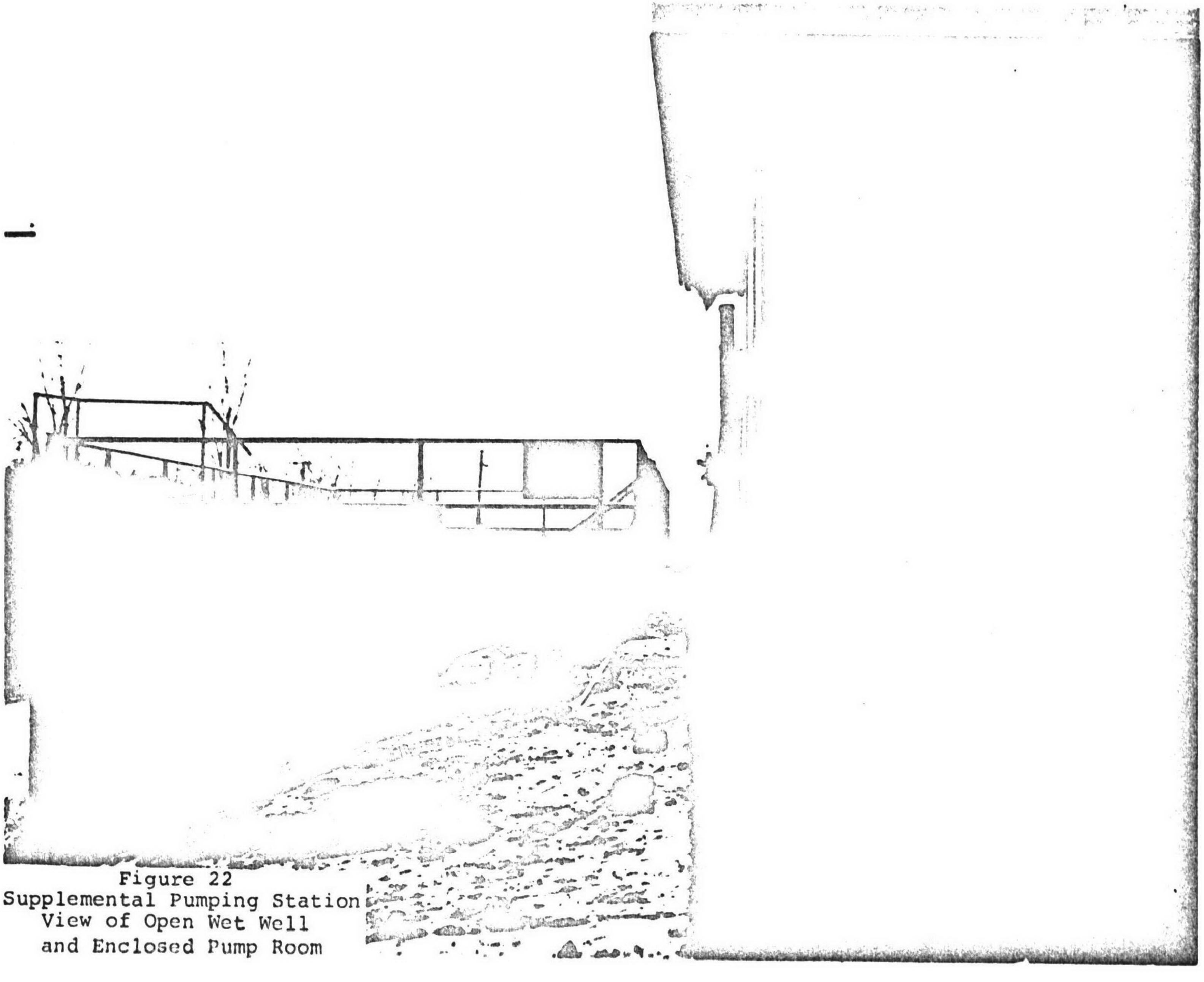


Figure 22
Supplemental Pumping Station
View of Open Wet Well
and Enclosed Pump Room

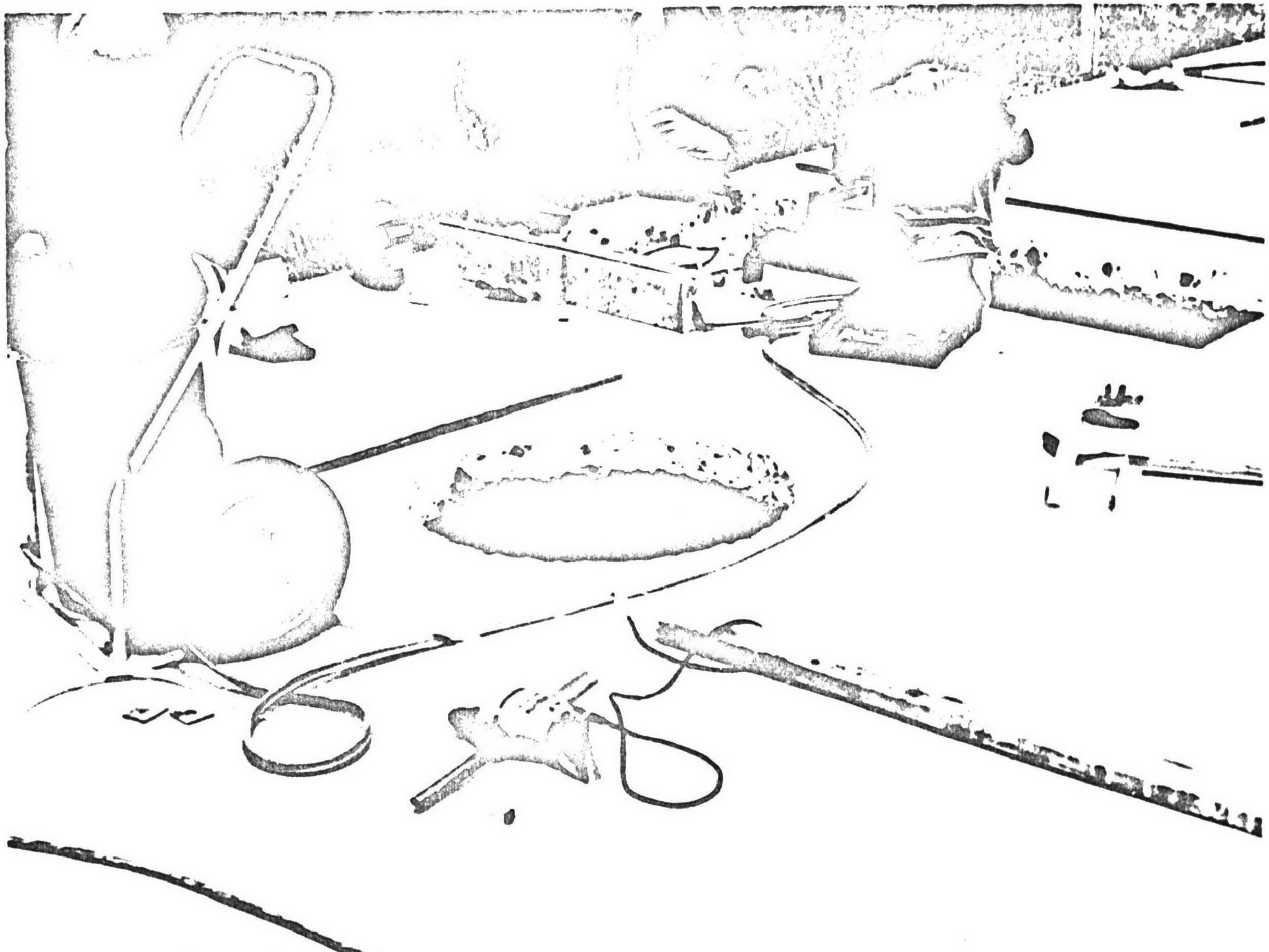


Figure 23
Diversion Structure
Breaking Out Openings for Discharge Pipe
and Temporary Bulkhead

3. Piping and Equipment: Two vertical nonclog raw sewage pumps with close-coupled wound motor drives, supported directly on the pump, were installed, Each pumping unit is capable of variable speed operation. Each unit is capable of pumping 50 mgd at maximum speed and 15 mgd at minimum speed. The pumps are provided with grease seals.

The suction of each pump is a 42-inch steel pipe with a 42-inch sluice gate at the end in the wet well for shutoff. A 36-inch steel discharge pipe with sleeve type couplings is provided from each pump forming a siphon at the top where it leaves the pumping station and discharges down into the nearby existing diversion structure.

Bar racks which may be cleaned manually are provided in the wet well ahead of the suction sluice gates. Figure 12 illustrates the arrangement of the piping and equipment.

The chlorination piping in the existing diversion structure was modified to provide facilities for the addition of chlorine downstream of the pump discharges. Valving is provided in the new chlorine piping so that the chlorine may be applied at the entrance of the 96-inch force main when the Main Pumping Station is in operation, or downstream of the Supplemental

Pumping Station pump discharges when the Supplemental Pumping Station is in operation.

Metering equipment include meters and registers for each pump suction and discharge pressure and the pump speed. With this information and the head-capacity curves for each pump, the approximate pumping rate for each pump may be determined. The meters and registers are located on an instrument panel inside the building at the ground floor level.

Provision for manual or automatic control of the pumps is provided in the pump control system. The variable speed control system for both pumping units consists of automatic speed control arranged to sense the liquid level in the wet well. The wet well level as sensed by the liquid level control adjusts the liquid rheostat connected in the secondary of the wound rotor motor for pump speed control. External heat exchangers are provided, for the liquid rheostat, consisting of a radiator and fan mounted outside the pumping station structure. The speed control is designed to start the lead pump, maintain a constant wet well level until the lead pump is at maximum speed then start the second pump and both pumps then operate at reduced speed maintaining a pre-set wet well level. An alarm system includes an annunciator on the pump control center and an outside horn and a flashing light to give an alarm in the event of equipment failure.

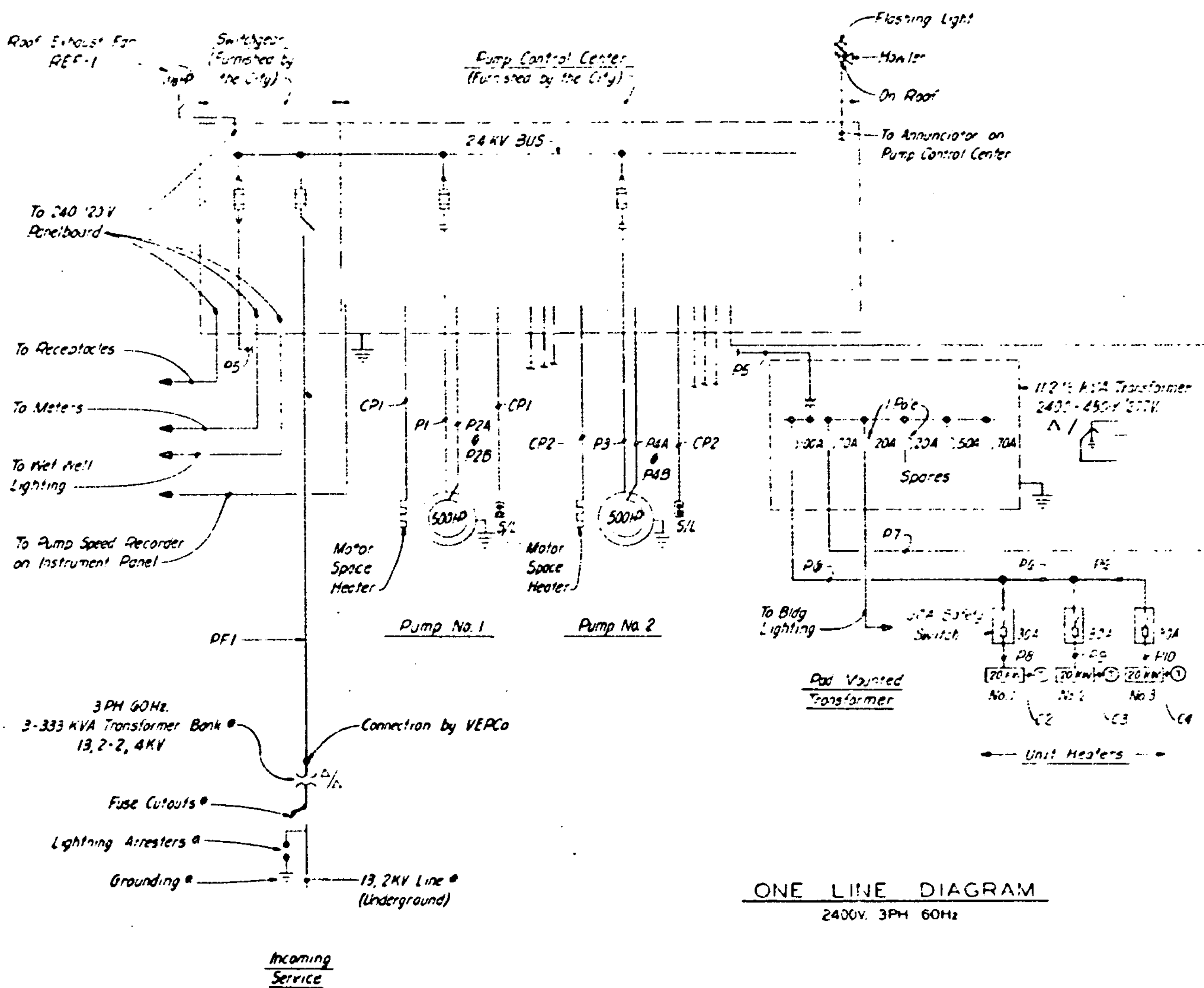
4. Electrical System: The electrical system for the Supplemental Pumping Station consists of a substation near the pumping station which is supplied from a 13.2 kv VEPCO overhead line and supplies power to the Supplemental Pumping Station at 2,400 volts.

An auxiliary station transformer located outside the pumping station structure is provided to supply station power at 480/277 volts for heating, ventilating, lighting and other auxiliaries.

The switch gear, primary control and secondary controls are mounted on a concrete slab at ground floor level inside the superstructure of the pumping station.

Figure 24 shows a simple one-line diagram for the station's electrical arrangement.

5. Heating and Ventilating: An exhaust fan with a capacity of 1,000 cfm mounted on the roof provides continuous ventilation of the Pump Room and dry well. The roof exhaust fan's duct carries down into the Pump Room or dry well to just above the pump suction connection providing an exhaust of about 6 changes per hour for an effective operating height of 10 feet. A 3-foot by 1-foot 4-inch high manually operated



ONE LINE DIAGRAM

2400V. 3PH 60Hz

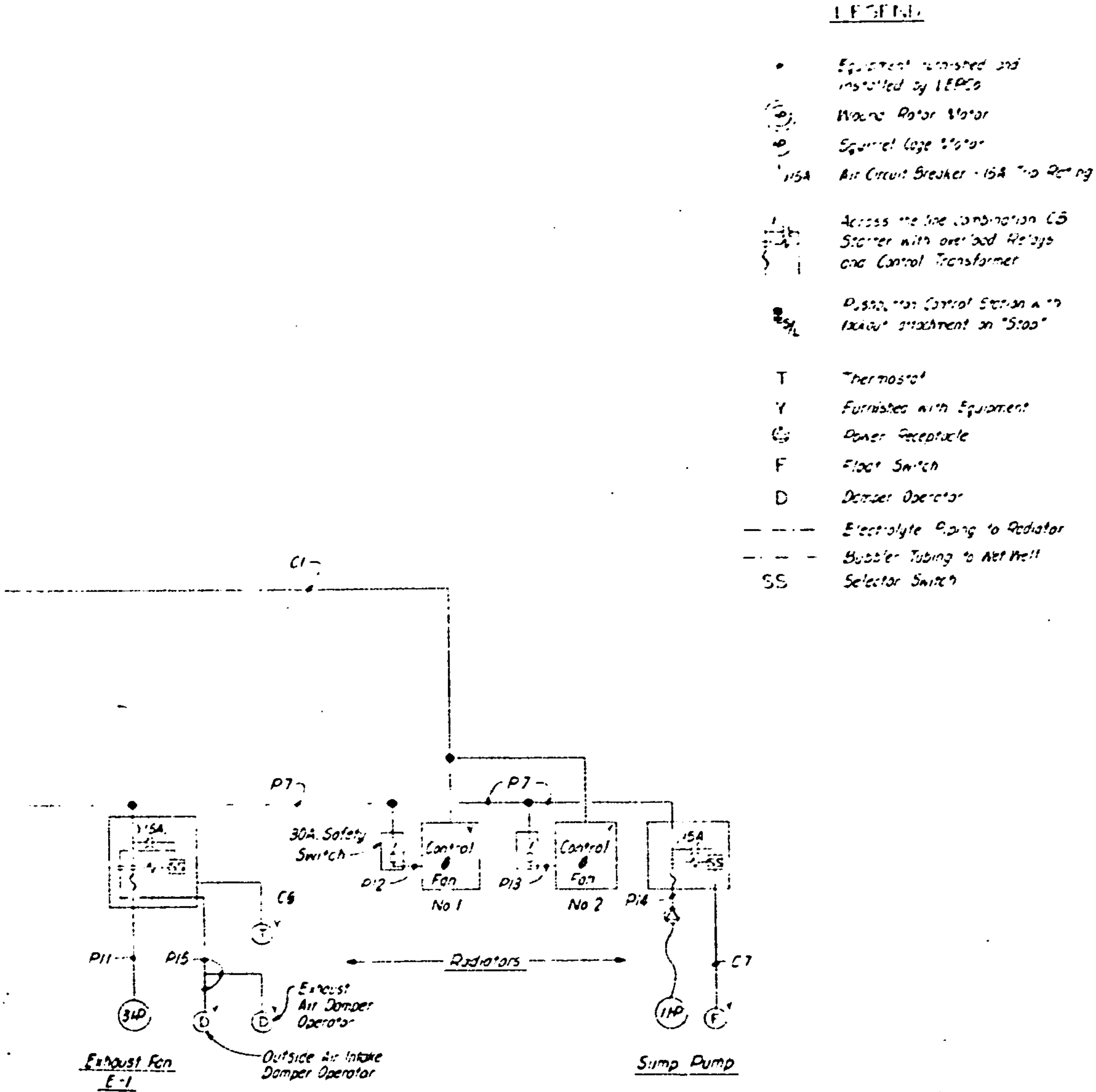


FIGURE 24

SUPPLEMENTAL PUMPING STATION ELECTRICAL - ONE LINE DIAGRAM

louver is provided in the superstructure wall to provide for the continuous air intake.

Another exhaust fan with a capacity of 6,000 cfm is mounted in the Pump Room about 10 feet above the lower floor. This fan is thermostatically controlled to provide heat removal and discharges through a gooseneck on the roof of the superstructure. Interlocked with this exhaust fan is a 4-foot by 8-foot high motor-operated louver located in the superstructure wall, which provides the intake to the superstructure of the required amount of outside air.

Three 20-kw thermostatically controlled electric unit heaters are provided for heating the Pump Room and superstructure.

B. Description of the "Bulkhead"

The installation of the bulkhead in the existing South Junction Chamber required design because of the unusual structural aspects.

The walls of the existing South Junction Chamber were not designed structurally to restrain the greater loads imposed on them by the increase in internal hydrostatic pressure; an 8-foot by 8-foot opening in the south wall leading to the Main Pumping Station was to be bulkheaded. The entire structure, including the north (back) wall and the side walls, was engaged, structurally, to carry the loads imposed by the severe hydraulic conditions after the installation of a bulkhead.

The bulkhead had to be installed while the sewage was flowing through the junction chamber. The bulkhead was prefabricated of welded steel plates, beams and angles with a 3-foot by 4-foot sluice gate mounted at the center near the bottom and rubber seals on both sides and the bottom. The bottom of the 8-foot by 8-foot opening was flat with no sill for bottom support of the bulkhead. It was necessary to design the bulkhead for very small deflections to prevent leakage.

The bulkhead was designed by a stiffness method using an IBM 360 computer. A program was developed which determined all reactions, shears and moments of all points considering the effects of the various deflections.

The bulkhead was structurally tied to the back wall with the use of tie rods and an anchor beam placed outside of the structure against the back wall. This permitted the hydraulic loads imposed on the bulkhead to be transmitted into the entire structure, even utilizing the side walls, and preventing the south wall from receiving the bulkhead loads for which it was not designed. Figure 10 illustrates the bulkhead as installed. It was necessary to remove a portion of the top of the concrete structure to permit the installation of the bulkhead.

Figures 25 to 30, inclusive, illustrate the installation and removal of the temporary prefabricated bulkhead placed in the inside south face of the special structure to divert raw sewage to the Supplemental Pumping Station while making connections to the new Grit Removal Facilities.

C. Method of Accomplishment and Costs

To obtain pumping equipment as quickly as possible, the pumping equipment was purchased with a separate contract prior to the design of the structure.

To obtain the most readily available equipment, the specifications permitted the furnishing of new or reconditioned pumping units consisting of two or three vertical or horizontal electric motor driven units. The type of controls permitted were squirrel-cage motors with adjustable speed magnetic drives, wound rotor motors with liquid rheostat variable speed controls in the secondaries of the motors. Two bid proposals were received for the above pumping equipment and controls. Both proposals were for new equipment. One proposal offered two vertical wound rotor motor drive units each with a maximum capacity of 50 mgd; the other proposal offered three horizontal units with wound rotor motor drives each having a maximum capacity of 30 mgd. Each proposal included liquid rheostat variable speed controls.

Although the bid prices of the three horizontal unit proposal was slightly less than that offered with the two unit vertical proposal, the two vertical units were selected

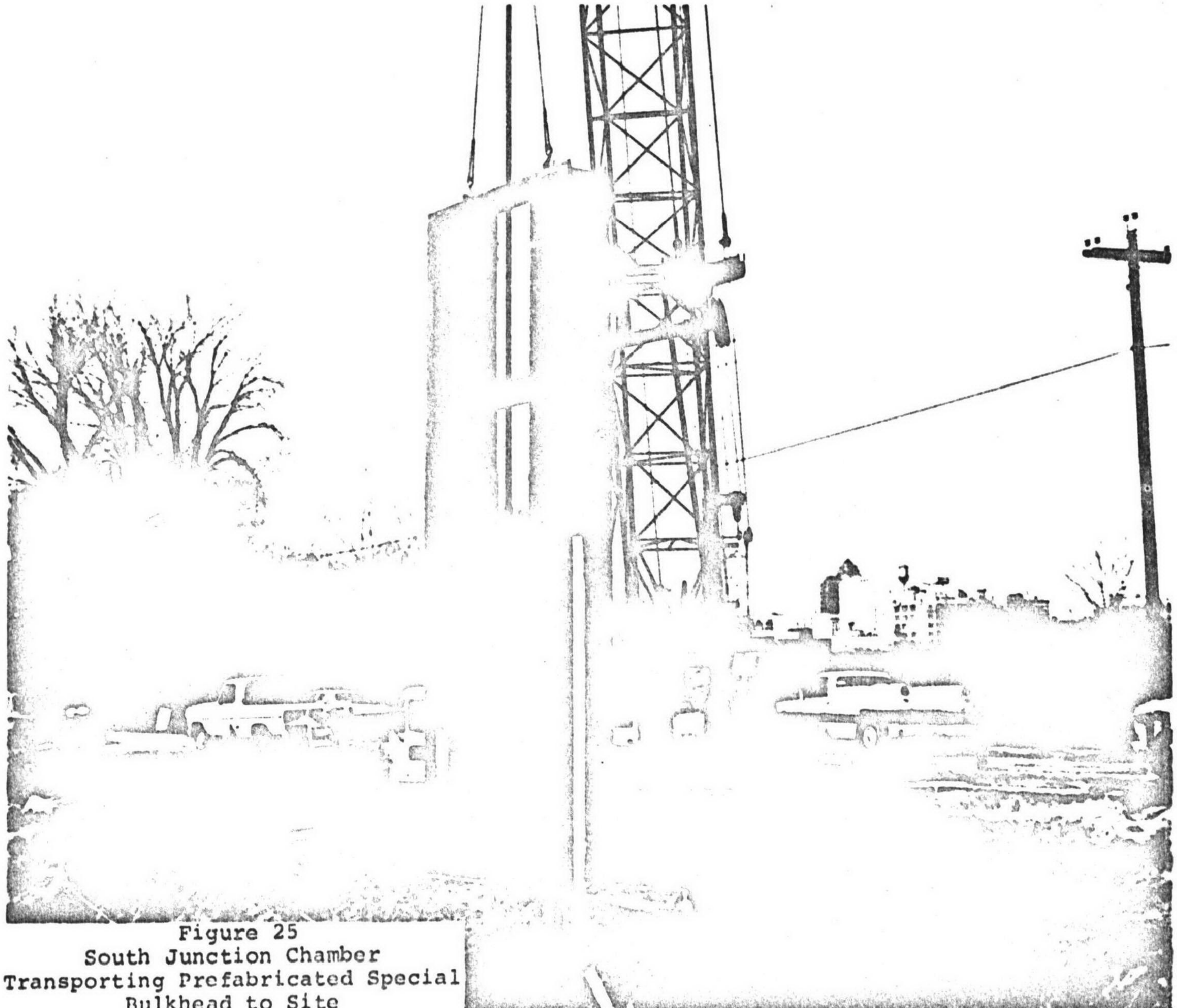


Figure 25
South Junction Chamber
Transporting Prefabricated Special
Bulkhead to Site

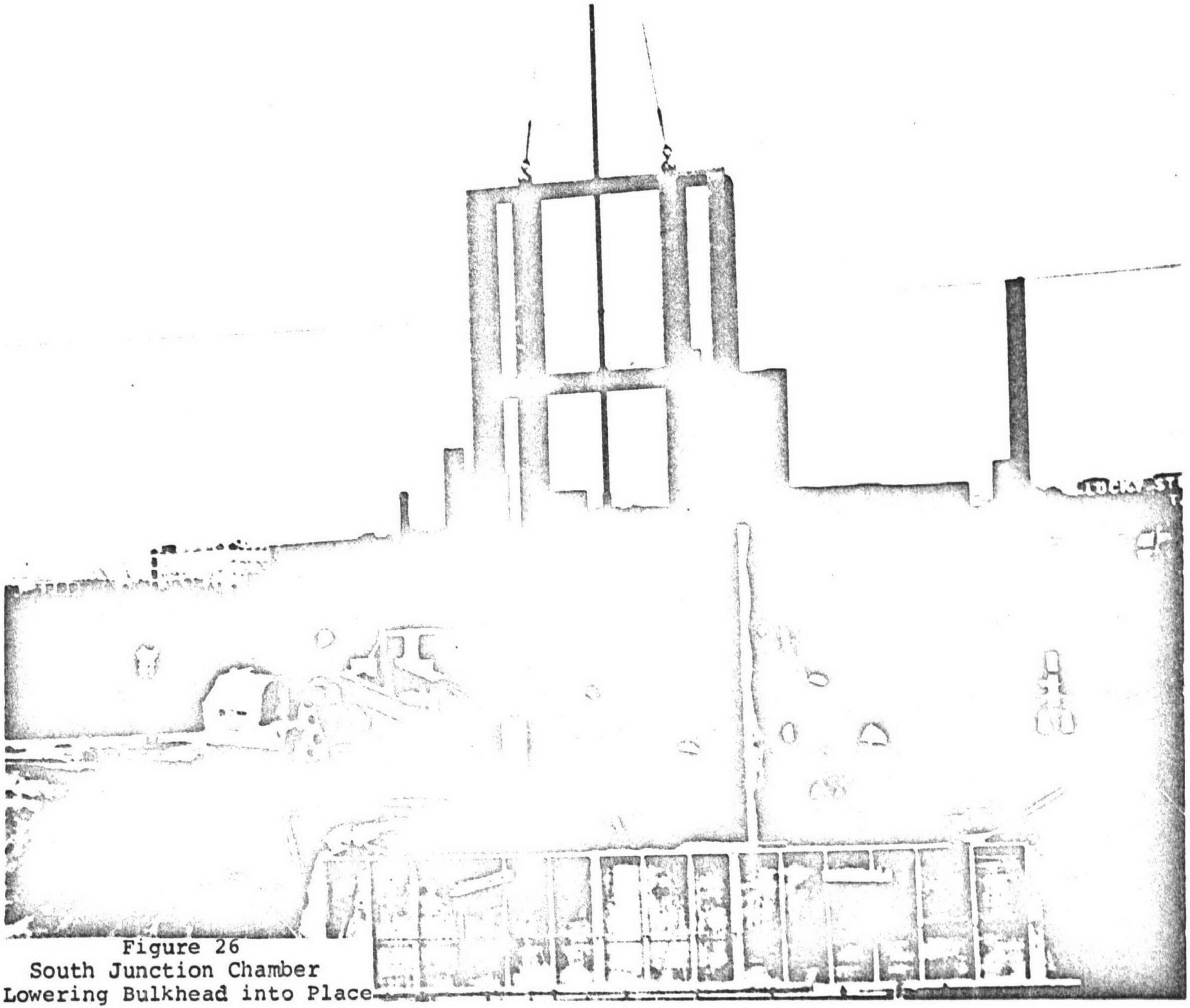


Figure 26
South Junction Chamber
Lowering Bulkhead into Place

Figure 27
South Junction Chamber
South Face of Chamber
Showing Bulkhead in Place

Figure 28
South Junction Chamber
Preparation for
Construction of New Junction Chamber

59

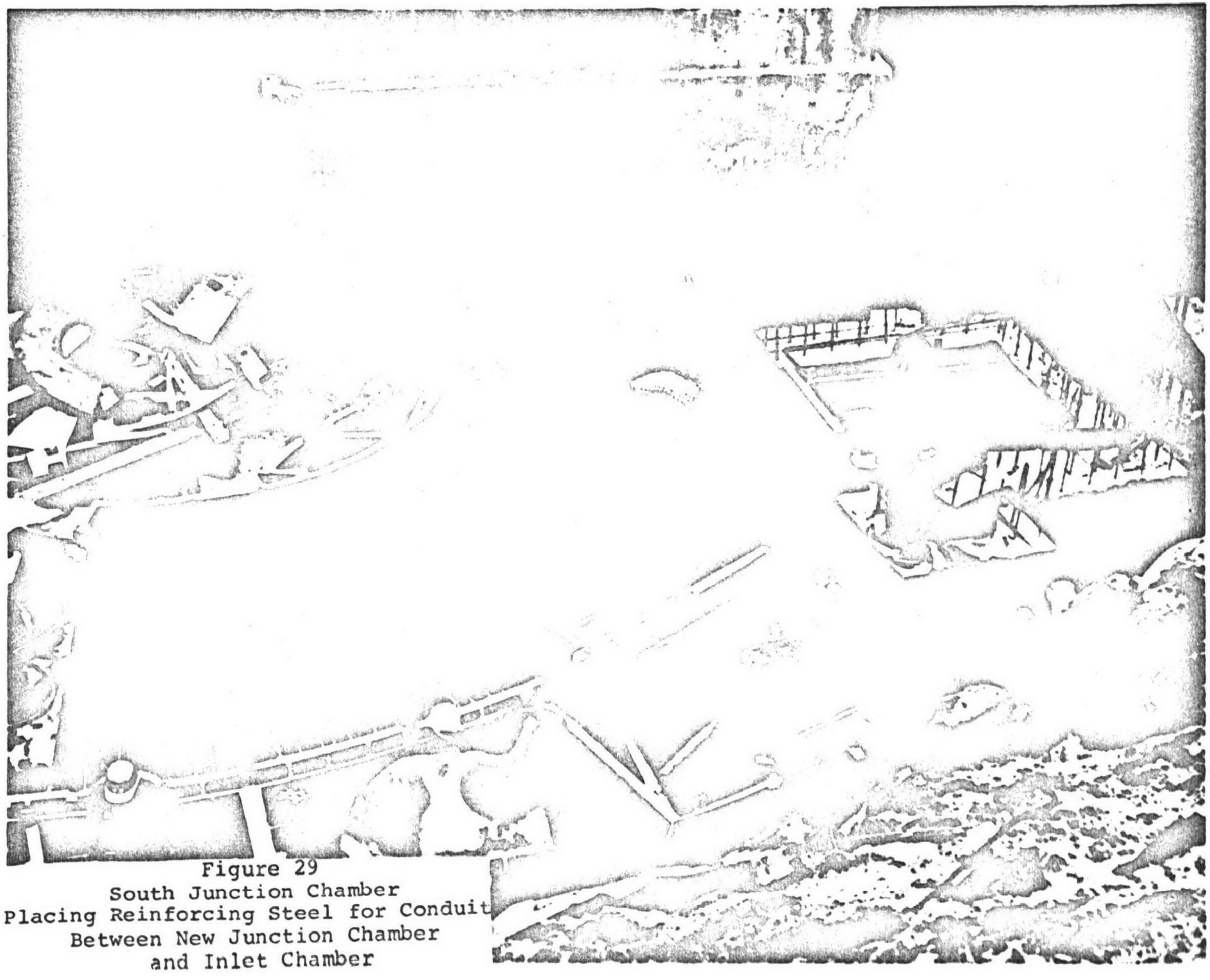


Figure 29
South Junction Chamber
Placing Reinforcing Steel for Conduit
Between New Junction Chamber
and Inlet Chamber

Figure 30
South Junction Chamber
Removal of Prefabricated Bulkhead

because a much smaller pumping station structure could be built and the savings in cost of the smaller structure would more than offset the small additional cost of the equipment. The total amount of the bid for the two vertical pumping units and all specified controls was $149,900.00.

D. Design Time

The design of the Supplemental Pumping Station and Appurtenances began in January, 1970. Bidding documents for the pumping equipment and controls were prepared and bids were received on May 14, 1970. The Contract was awarded on June 23, 1970, and the design of the Supplemental Pumping Station was begun to accommodate the specific equipment to be provided. On July 20, 1970, the preliminary Plans were reviewed with representatives of the Federal Water Quality Administration, the Virginia State Health Department and the Virginia State Water Control Board. The design concept was approved at that meeting, and at the end of July, 1970, the FWQA approved the Plans for the Supplemental Pumping Station. All design work was completed and negotiations with Contractors were begun for the accomplishment of the Contract work. Contracts and change orders to existing contracts were signed in December, 1970, and on-site construction was begun February 19, 1971.

SECTION V

THE CONSTRUCTION

The design of the facilities necessary to avoid bypassing was initiated following acceptance of the Grant Offer on January 26, 1970. The work was to be developed in two parts; pumping equipment and the Supplemental Pumping Station structure itself.

On April 21, 1970, the Federal Water Quality Administration approved the Plans and Specifications for the pumping equipment. The contract was advertised on April 24, 1970, with bids to be received on May 14, 1970. The award of the contract was approved by the FWQA and the contract was subsequently executed on June 24, 1970. Pump tests were witnessed on January 25 and 26, 1971. All equipment under the contract was received by the end of May, 1971.

The preliminary design of the "Supplemental Pumping Station - Structures" and the design of the temporary bulkhead for the existing junction chamber were substantially complete by June 11, 1970. A meeting was held on July 20, 1970, to review the cost estimates for the pumping station and bulkhead. Present at this meeting were representatives of the Federal Water Quality Administration, the State Health Department, the State Water Control Board and the consultants of the City of Richmond.

At the meeting, the plans for the pumping station structures were submitted for approval. As a result of that meeting, it was agreed to redesign the electrical service to realize a savings of approximately $7,000 and to eliminate the Dahl flow tubes. These changes were to be incorporated in a change order to the work presently underway at the Wastewater Treatment Plant.

The Federal Water Quality Administration notified the City on July 29, 1970, that they approved the design of the Supplemental Pumping Station - Structures, incorporating the changes discussed in the July 20, 1970 meeting.

Actual construction of the Supplemental Pumping Station - Structures was begun on February 19, 1971, with the driving of sheet piling completed on April 7, 1971. Excavation was essentially complete by September 4, and concrete work was accomplished between September 10 and November 23, 1971. The assembly of the superstructure, electrical work and the installation of equipment and controls were all undertaken during the period from November 23, 1971 to February 1, 1972.

In addition to the two main parts of this project, (pumping equipment and pumping station structure) numerous smaller projects were necessary to allow the Supplemental Pumping Station to function properly. These various projects were achieved through change orders and various contracts. The various Contract Divisions for work at the Wastewater Treatment Plant, the change orders, separate contracts, dates of issue and a brief description of the work covered by each change order or contract are summarized below:

Contract	Change Order Number	Date	Description
Div. X	7	4-17-70	For furnishing all labor, material and equipment for the construction of the following items (see proposal by Contractor dated April 13, 1970, and proposed construction procedure): 1. Outfall Chamber No. 3, as illustrated on Supplementary Sheets 4 to 6, inclusive revised March 19, 1970. 2. New Diversion Chamber and Sewer as illustrated on Supplementary Sheets 1 and 2, dated October, 1968.
Div. X	9	10-10-70	Change Order No. 9, "Modification of Junction at River Crossing" per letter of January 9, 1970, from the City Manager addressed to the State Water Control Board, including Attachment "A". Part D of Attachment "A", Modification of Junction at River Crossing - Construction Grant. (See English Construction Company, Inc. proposal dated September 25, 1970, and Plan Sheets Nos. 1, 2 and 3 with Specifications.

Contract	Change Order Number	Date	Description
Divs. XII and XIII	2	9-2-70	For furnishing all labor, materials and equipment for construction of a sluice gate chamber in the existing raw sewage conduit adjacent to the existing primary tanks (See Supplemental Sheet No. 2 and English Construction Company proposal).
Divs. XII and XIII	3	10-10-70	Research and Development on a Supplemental Pumping Station and on the Modification of Junction at River Crossing per letter of January 9, 1970, from the City Manager addressed to the State Water Control Board including Attachment "A". Part A of Attachment "A" - Pumping Facilities Research and Development Grant. (See Part A of English Construction Company, Inc. proposal dated September 23, 1970 and Plan Sheets Nos. 1 through 13, with Specifications). Part D of Attachment "A" - Modification of Junction at River Crossing - Research and Development Grant (See English Construction Company Inc. proposal dated September 23, 1970, and Plan Sheets Nos. 1, 2 and 3 with Specifications).

Contract	Change Order Number	Date	Description
Divs. XII and XIII	4	10-10-70	Construction of a Supplemental Pumping Station and Modifications of Diversion Structure per letter of January 9, 1970 from the City Manager addressed to the State Water Control Board including Attachment "A". Part A of Attachment "A", Pumping Facilities - Construction Grant. (See Part A of English Construction Company, Inc. proposal dated September 23, 1970 and Plan Sheets Nos. 1 through 13 with Specifications). Part B of Attachment "A", Modification of Diversion Chamber - Construction Grant. (See Part B of English Construction Company, Inc. proposal dated September 23, 1970 and Plan Sheets Nos. 1 through 13).
Divs. XII and XIII	5	10-21-70	For furnishing materials and labor for construction of and installation of a steel bulkhead in the effluent channel of the existing Preliminary Sedimentation Tanks per Supplemental Sheet No. 3 and the English Construction Company proposal of October 19, 1970. This work is to be accomplished with the existing plant in operation.

Contract	Change Order Number	Date	Description
Supplemental Pumping Station - Furnishing Pumping Equipment		6-24-70	Furnishing and delivering complete, the new or reconditioned used pumping equipment consisting of two or three vertical or horizontal, electric motor-driven pumping units and all equipment to provide a complete pump control system.
Supplemental Pumping Station - Furnishing Pumping Equipment		5-19-71	For furnishing a ground detection alarm system, fused switch and additional motor starters, and the deletion of the window-type current transformers and ground fault relays. No extension of time is required.
Electrical Substation		3-22-71	Furnishing and installing the transformers, poles, fence, and related equipment to completely construct the substation.

The existing diversion structure was altered during the period September through November, 1971, with the installation of a wooden bulkhead.

Work on the connection of the grit removal facilities continued until the Wastewater Treatment Plant was flooded in June, 1972. At the time of that flood, work was essentially complete on construction required for connection of the grit channels. Following the emergency repair work was begun on the Grit Removal Facilities. This period of repair required approximately three months. By August, 1972, it was anticipated that connections could be made and the Supplemental Pumping Station could be shut down about the beginning of October.

The flood in the early part of October forced the station out of service from October 6 through October 9, 1972. Once again, the grit channels were flooded and repairs were completed by the beginning of December.

Attempts to reactivate the Main Pumping Station were hampered by damage caused by the flooding and idleness, but undetected during repair work. Complete repair work on the Supplemental Pumping Station made necessary by the June, 1972 flood could not be accomplished until the Main Pumping Station was reactivated. The floods of June and October, 1972, caused a delay of approximately seven months in the completion of the supplemental pumping operations.

The flood of August, 1969, while not occuring during the construction of the Supplemental Pumping Station and appurtenances did contribute to delays in the construction schedule for the Grit Removal Facilities. The intended period of plant shutdown had to be delayed from September 15, 1969, until November 1, 1969. Before the plant shutdown was to begin, however, bypassing was ruled out and circumstances led to the filing of the grant application on November 14, 1969.

Initiating Construction

The connection between the South Junction Chamber and the Main Pumping Station was closed by the installation of the specially designed bulkhead. Modifications to the South Junction Chamber and preparatory work for the installation of the temporary bulkhead was begun on October 12, 1971, and was completed by January 31, 1972. At that time an attempt was made to install the bulkhead in accordance with the suggested procedure outlined in Figure 8. The attempt to install the temporary bulkhead was unsuccessful because the Contractor failed to ascertain a dimension in the field as stipulated in the design Plans. The bulkhead was removed, altered and reinstalled on February 1, 1972. Final adjustments on equipment and controls in the Supplemental Pumping Station were made between February 2 and February 9, 1972, when the sluice gate was closed on the temporary bulkhead in the South Junction Chamber and the Supplemental Pumping Station went into full operation. The temporary bulkhead sealed the opening excellently, allowing very little leakage.

Termination of Construction

In December, 1972, the sluice gate in the temporary bulkhead was opened at various times to test the operation of the grit channels and the Main Pumping Station. These tests were run on an intermittent basis until January 3,

1973. By February 14, 1973, preparations were being made to restore the structure and equipment to preflood conditions.

The chronology of principal events bearing on the development and progress of the work associated with the Supplemental Pumping Station is shown graphically on Figure 31. The construction costs are summarized as follows:

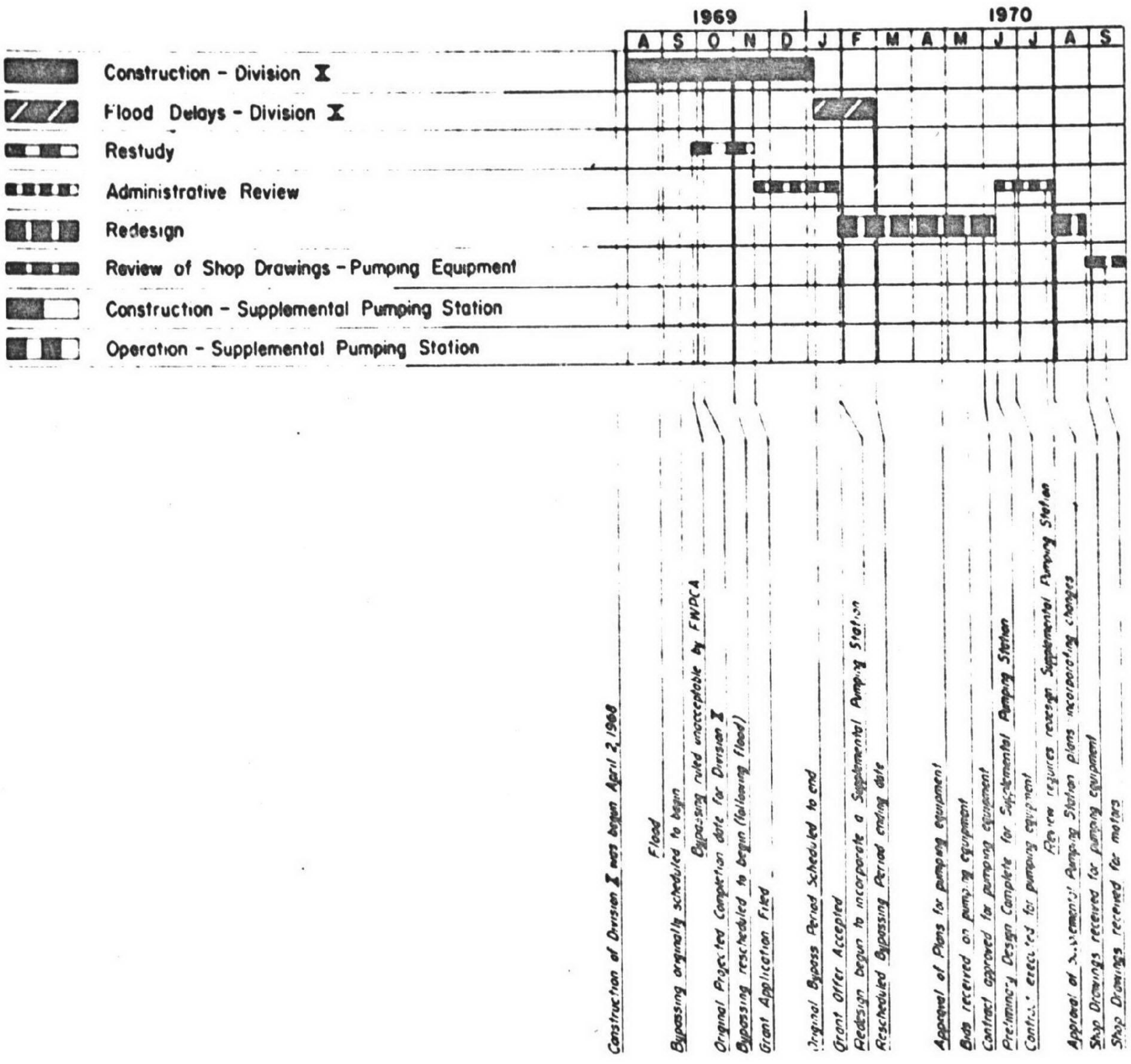
Contract		Cost
Div. X	Outfall Chamber No. 3 and New Diversion Chamber	$ 81,467.00
	Modification of South Junction Chamber	24,900.00
		$106,367.00
Divs. XII and XIII	Sluice Gate Chamber at Primary Tanks	12,800.00
	Mech. & elec. work	145,100.00
	P.S. & Diver. Structure	317,400.00
	Bulk. in Primary Tanks	7,495.00
		$482,795.00
Electrical	Substation (original Contract)	10,470.00
Subtotal -	Structures and Appurtenances Cost	$599,632.00
Supplemental Pumping Station, Furnishing Pumping Equipment	(original Contract)	149,900.00
	Electrical controls	2,139.30
Subtotal -	Furnishing Pumping Equipment Cost	$152,039.30
Total Construction Cost		$751,671.30

The total cost for pumping equipment is $152,039.30 and the cost of the Supplemental Pumping Station and appurtenant structures is $599,632.00, including the cost of the Virginia Electric and Power Company work on the electrical substation. The total of all construction costs associated with the Supplemental Pumping Station and Appurtenances is $751,671.30.

Summary

The total cost of the Supplemental Pumping Station and appurtenant work has been defrayed in part by Research and Development Grants and in part by local funds. The allocation of costs is as follows:

	Const. Grant	R & D Grant	Total
Engineering	36,095.34	1,576.61	37,671.95
Construction	454,532.00	297,139.30	751,671.30
Operation	-	99,734.93	99,734.93
Administration	-	6,479.78	6,479.78
Total	$490,627.34	$404,930.62	$895,557.96



1969
1970
A
S
O
N
D
J
F
M
A
M
J
J
A
S
Construction - Division X
Flood Delays - Division X
Restudy
Administrative Review
Redesign
Review of Shop Drawings - Pumping Equipment
Construction - Supplemental Pumping Station
Operation - Supplemental Pumping Station
Construction of Division X was begun April 2, 1968
Flood
Bypassing originally scheduled to begin
Bypassing ruled unacceptable by FWPCA
Original Projected Completion date for Division X
Bypassing rescheduled to begin (following flood)
Grant Application Filed
Original Bypass Period Scheduled to end
Grant Offer Accepted
Redesign begun to incorporate a Supplemental Pumping Station
Rescheduled Bypassing Period ending date
Approval of Plans for pumping equipment
Bids received on pumping equipment
Contract approved for pumping equipment
Preliminary Design Complete for Supplemental Pumping Station
Review requires redesign Supplemental Pumping Station
Approval of Supplemental Pumping Station plans incorporating changes
Shop Drawings received for pumping equipment
Shop Drawings received for motors

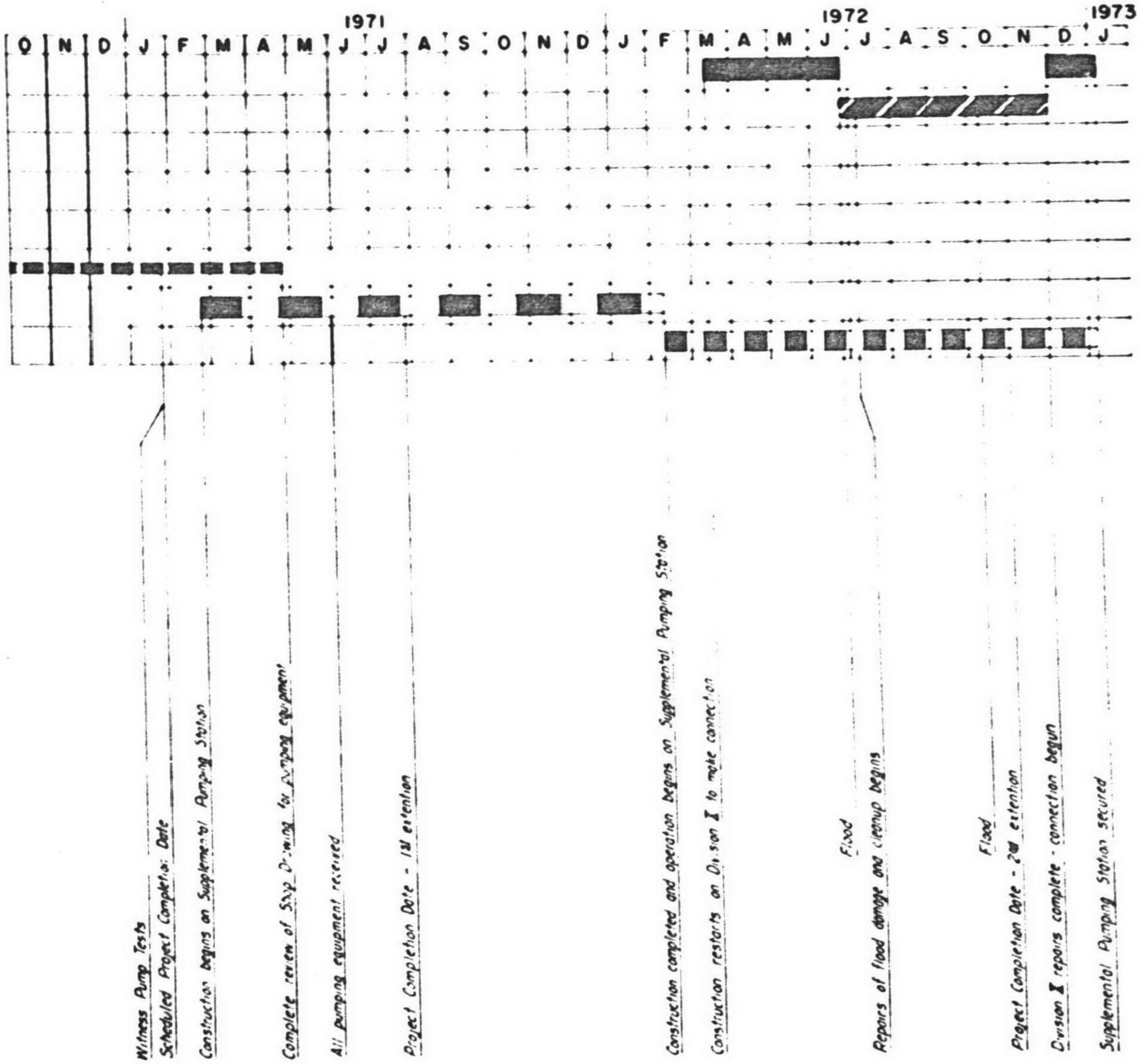


FIGURE 31

CHRONOLOGY

SECTION VI

THE OPERATIONS

A. Operation Phase

The Supplemental Pumping Station was tested on February 3, 1972, for a period of 7 hours. On February 9, 1972, the station began full-time operation at 9:10 A.M. The first full day of operation was February 10, 1972, and the station continued to operate until the flood caused a shutdown at 12:00 P.M. on June 22, 1972. The station was restarted at 11:30 P.M. on July 3, 1972.

Another flood required the station to be shut down from 6:00 A.M. October 6, 1972, to approximately 8:00 P.M. October 9, 1972.

The Supplemental Pumping Station was shut down on January 21, 1973, and the Main Pumping Station was restored to service.

At the time of the initial start-up of the Supplemental Pumping Station, it was anticipated that the connection to the New Grit Chamber could be made during the month of June, 1972. The flood of June, 1972, damaged motors, controls and other equipment in the Supplemental Pumping Station and the transformers at the VEPCO substation. The two 500-horsepower motors were removed with a crane through a hole cut in the roof of the station and sent to the General Electric service facility in Richmond. One of the motors was returned and remounted on July 3, 1972. This installation was used to pump and chlorinate a portion of the sewage flow. The second motor was returned and installed on July 4. The station was operated manually, since the automatic controls were still damaged. The transformers in the VEPCO substation were also repaired by the local General Electric service facility.

By August, 1972, repairs on flood damage to the new grit tanks had progressed sufficiently to expect that connection could be made at the beginning of October. The flood in October once again flooded the grit tanks and caused damage. The Supplemental Pumping Station had been stripped of readily removable equipment and required only that it be pumped out and washed down before the electrical equipment could be reinstalled.

Repairs to the grit tanks were essentially completed in November and connection was scheduled for December. During December, 1972, and January, 1973, repeated attempts were made to reactivate the Main Pumping Station with the new grit tanks on line. Operational problems were attributed to the flooding of equipment and to the long period during which the equipment remained idle. The problems were finally resolved and the Supplemental Pumping Station was secured on January 21, 1973.

B. Operation and Maintenance

Staff

The staff required for the operation and maintenance of the Supplemental Pumping Station has been drawn from the personnel regularly employed at the Wastewater Treatment Plant. Overall daily supervision was provided by the plant superintendent and this required approximately ten percent of his time. Five shift supervisors provided immediate supervision of operating personnel and this required ten percent of their total time. The total of eight shift operators spent approximately 100 per cent of their time attending the equipment. These eight operators comprised four gas engine operators and four gas engine attendants. These men were normally employed in the Main Pumping Station and are familiar with large pumping equipment and drives.

Control System

The Supplemental Pumping Station operated in response to an increase or decrease in the wet well level. The primary control sensor for automatic pump operation was an air bubbler tube suspended in the wet well. The pressure changes on the bubbler system caused by fluctuations in the sewage level in the wet well were converted to an electric signal which controlled pump motor speed and pumping sequence. The "start" and "stop" sequence of the infinitely variable speed pump motors could be selected and the wet well elevation at which the pumps start and stop was adjustable. The approximate elevations were as follows:

	Start	Stop
Lead pump	El.-5.5	El.-5.6
Second pump	El.-4.75	El.-4.85

The sequence of operation used with this control system is described as follows:

1. When the wet well level reaches the "start" elevation for the "lead" pump, the motor shall start at minimum speed.
2. The "lead" unit shall increase in speed as the wet well level tends to rise. It shall increase in speed to the maximum pump speed maintaining a constant level.
3. When the "lead" unit has reached its maximum speed and the wet well level has risen to the corresponding level for the "start" of the second unit, the "second" pumping unit shall start. The "lead" unit and "second" unit shall adjust to the same speed.
4. The "lead" unit and "second" unit shall increase in speed as the wet well level tends to rise. They shall increase in speed to their maximum pump speed with the rising level.
5. As the wet well level tends to drop, the "lead" unit and "second" unit shall decrease in speed until their total capacity is less than the capacity of the "lead" unit running at maximum speed. The "lead" unit shall immediately increase in speed so its capacity equals the total before the "second" unit stopped.

6. As the wet well level tends to drop, the "lead" unit shall decrease in speed to maintain a constant level until its capacity is that of the unit running at minimum speed. At this time the "lead" unit shall stop.

The characteristic curves of the two pumping units installed in the Supplemental Pumping Station are presented as Figure 32.

C. Data Collected

Data collected on a regular basis during operation of the Supplemental Pumping Station include: James River water quality data, pumping unit suction and discharge pressure, pumping unit rotational speed, operating logs, a diary maintained by the resident engineer at the treatment plant, and the treatment plant operating records.

The river water quality data is based on weekly samples taken by the Richmond Department of Public Utilities at six stations on the James River. Samples are analyzed for temperature, pH, dissolved oxygen, 5-day BOD, total bacteria and coliforms.

Pumping unit suction and discharge pressure and rotational speed were recorded on 24-hour recording charts. Each unit has, therefore, three separate operational charts for each 24-hour period.

Operating logs were maintained by the treatment plant personnel on a 24-hour basis. The information regularly recorded on these logs was:

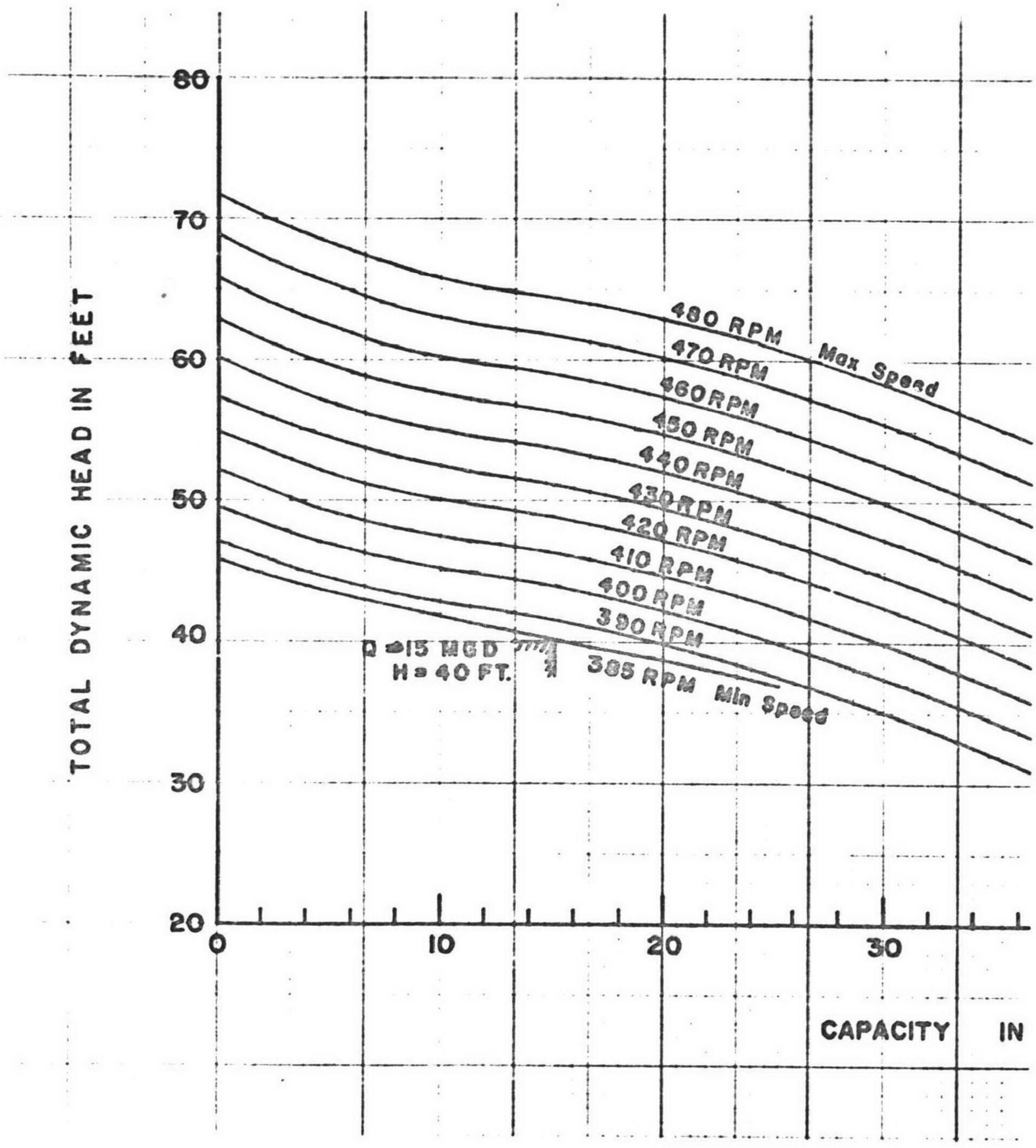
Wet well level
Pump hour meters
Watt hour meters
Suction and discharge pressure

In addition, operator's comments were recorded.

The resident engineer's diary provides a record of construction and operation sequences and describes activities and problems encountered during the project.

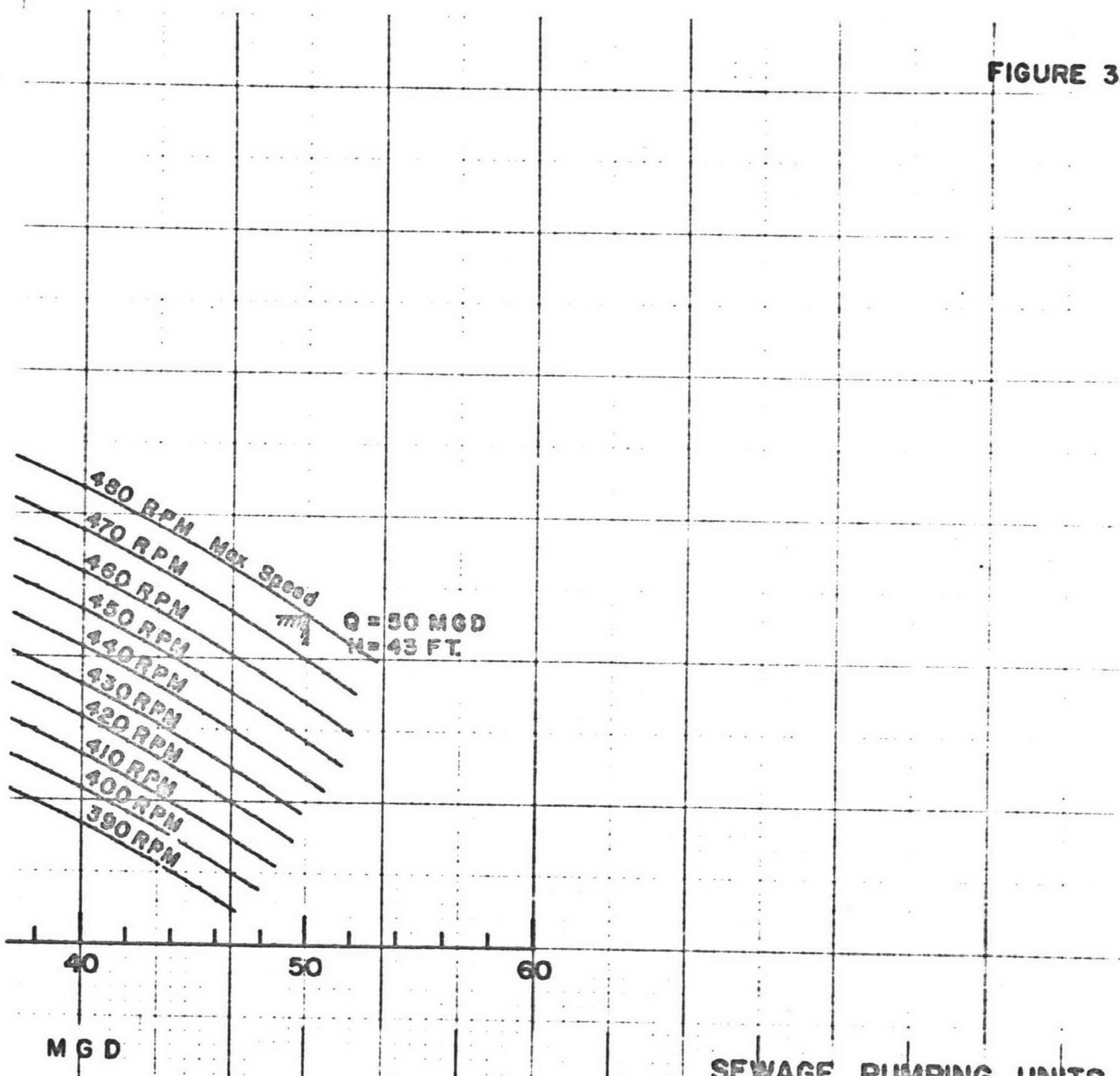
D. Evaluation of Data

The available data on pump speed, suction and discharge head and the pump characteristic curves can be used to estimate the amount of sewage handled by the Supplemental Pumping Station. The development of the complete pumping record from their data would involve extensive data logging and computations. The treatment plant records, therefore, have been studied to establish an alternate record of pumpage. The treatment plant flow record is obtained from an effluent weir. Comparison of the flow data from the two sources for selected periods of operation indicate good correlation. The flow data reported herein, therefore, is that obtained from the effluent weir at the treatment plant. An estimated curve showing comparison of the two sources of flow data is included as Figure 33.



TOTAL DYNAMIC HEAD IN FEET
80
70
60
50
40
30
20
0
10
20
30
CAPACITY IN
480 RPM Max Speed
470 RPM
460 RPM
450 RPM
440 RPM
430 RPM
420 RPM
410 RPM
400 RPM
390 RPM
385 RPM Min Speed
Q = 15 MGD
H = 40 FT.

FIGURE 32



SEWAGE PUMPING UNITS
CHARACTERISTIC CURVES

Note:
Supplemental Pumping Station flow values were computed from chart records.

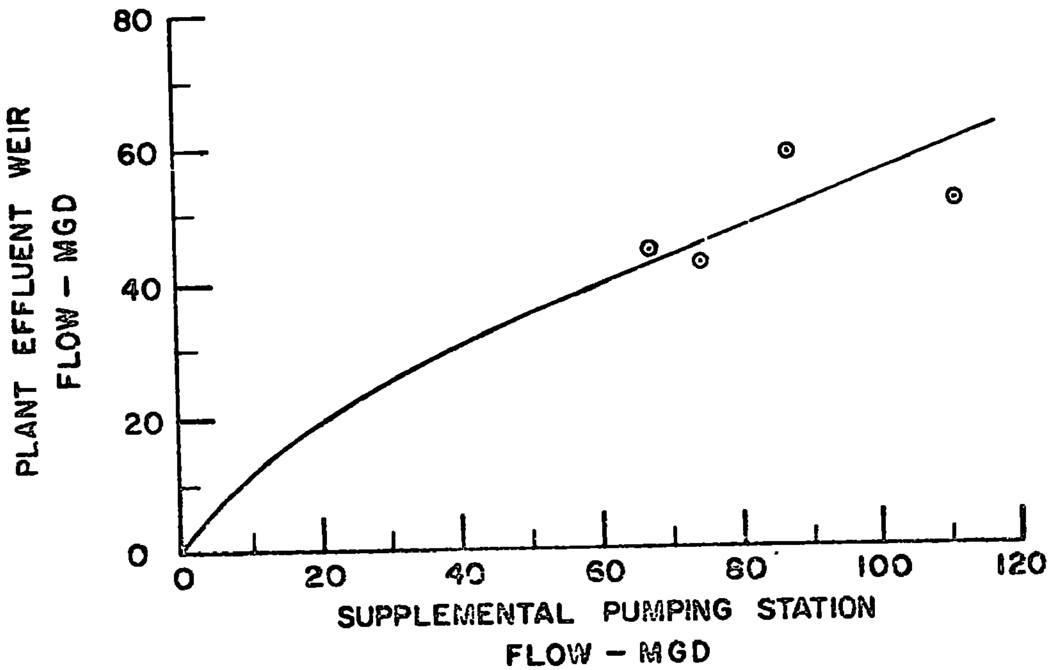


FIGURE 33

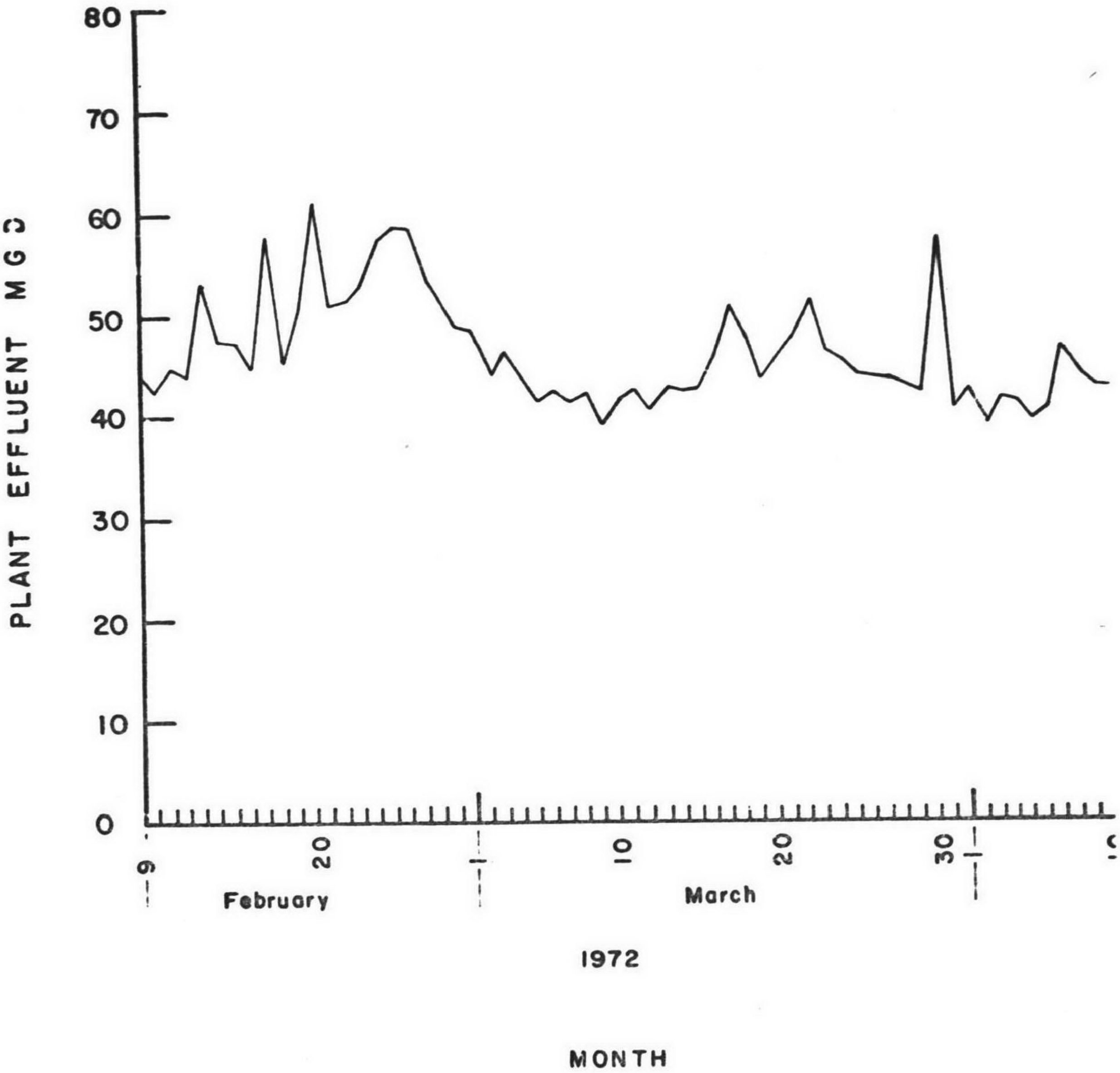
CALIBRATION CURVE
PLANT EFFLUENT WEIR VS SUPP. P. STA. FLOW

Complete flow records are available for the period beginning with the start-up of the Supplemental Pumping Station and ending with the facilities shutdown caused by flooding. A record of daily flow averages for that period is presented on Figure 34. During this period of record, the maximum daily average flow was 61.3 mgd on February 20, 1972. The minimum daily average flow of 36.6 mgd was handled on May 3, 1972. The estimated average daily flow handled by the Supplemental Pumping Station during the period when the weir was out of service was 42.6 mgd, based on the previous 418 days of plant operation.

The monthly averages of flow received and pumped for the period covering the operation of the Supplemental Pumping Station and nine months previous are shown in Table 1. These figures are presented to indicate the periods for which flows had to be estimated.

The total flow pumped prior to and after the floods is 13,125 mg.

The estimated amount bypassed due to the floods is 680 mg, which is approximately 4.5 percent of the total flow tributary to the treatment plant during the project.



PLANT EFFLUENT MGD
80
70
60
50
40
30
20
10
0
9
20
1
10
20
30
1
February
March
1972
MONTH

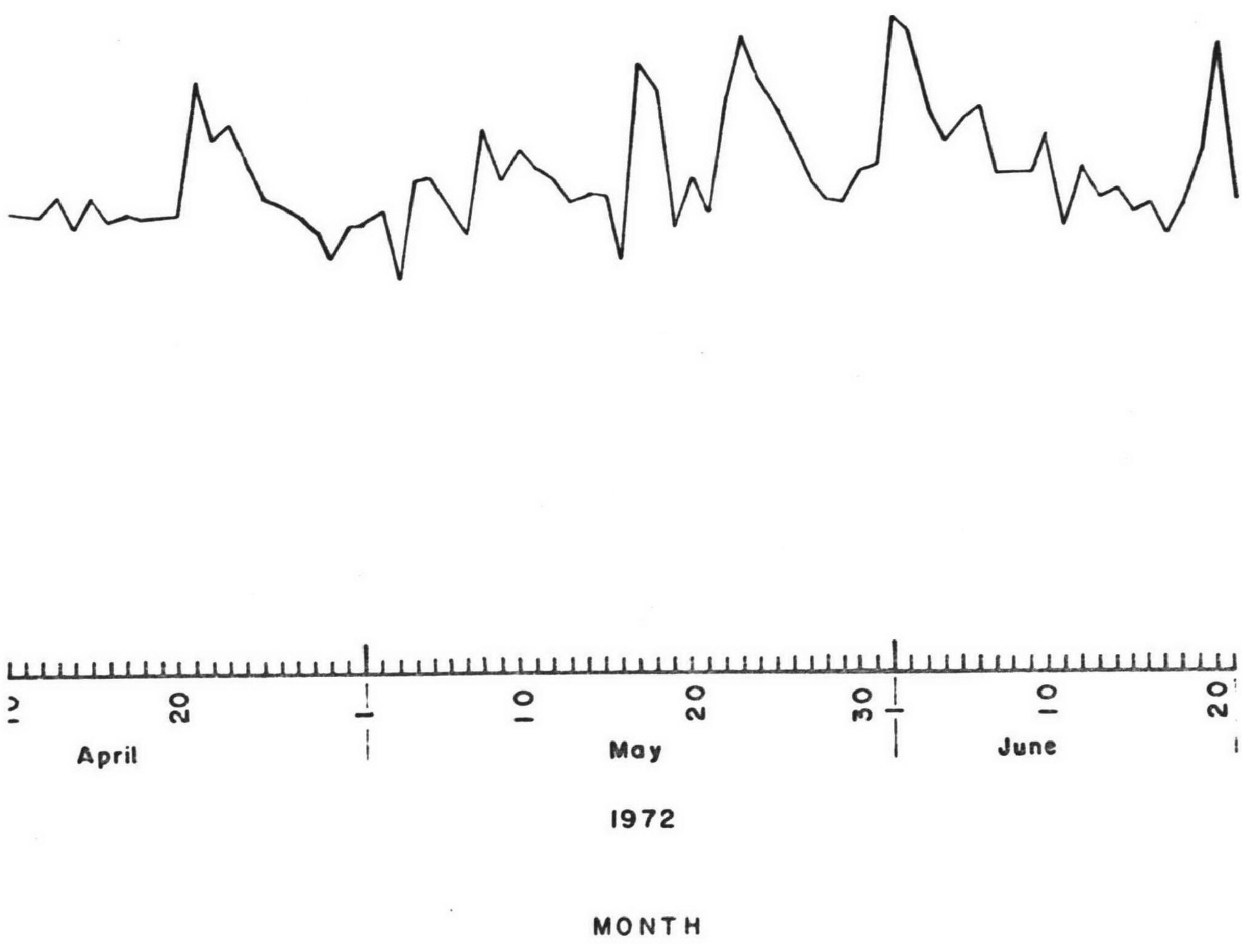


FIGURE 34

WASTEWATER TREATMENT PLANT
PLANT EFFLUENT FLOW

TABLE 1

RICHMOND, VIRGINIA

MONTHLY FLOW SUMMARY

	MONTH	NUMBER OF DAYS	AVERAGE FLOW MGD	MAIN P.S. FLOW MG	SUP.P.S. FLOW MG	DIFFERENCE MG	TOTAL FLOW MG
1971	(May	31	41.183	1,280			1,280
	(June	30	46.132	1,380			1,380
PRIOR TO	(July	31	37.714	1,170			1,170
OPERATION	(Aug.	31	40.672	1,260			1,260
	(Sept.	30	40.638	1,220			1,220
	(Oct.	31	46.932	1,450			1,450
	(Nov.	30	39.017	1,170			1,170
	(Dec.	31	35.204	1,090			1,090
1972	(Jan.	31	39.703	1,230			1,230
	Feb. (*1)	29	49.822	390	1,050		1,440
	March	31	44.497		1,380		1,380
	April	30	43.390		1,300		1,300
	May	31	46.406		1,440		1,440
	June (*2)	30	47.958		1,000	390	1,390
	July (*2)	31	42.6		1,180	140	1,320
	Aug.	31	42.6		1,320		1,320
	Sept.	30	42.6		1,280		1,280
	Oct. (*3)	31	42.6		1,170	150	1,320
	Nov.	30	42.6		1,280		1,280
	Dec.	31	42.6	660	660		1,320
1973	Jan. (*4)	31	42.6	65	65		130
TOTALS DURING OPERATION OF THE PUMPING STATION				1,115	13,125	680	14,920

(*1) Supplemental P. S. began operations at 9:00 A. M., February 9.
(*2) Flood - S.P.S. out of operation 10 days and 23 1/2 hours between June 22 and July 3.
(*3) Flood - S.P.S. out of operation 3 days and 14 hours between October 6 and 9.
(*4) Through January 3, when the Supplemental Station was put on standby.

SECTION VII

DISCUSSION

A. General

The purpose of providing a Supplemental Pumping Station was to protect the water quality of the James River. Available water quality data is based on weekly samples taken by the Richmond Department of Public Utilities. The sampling points along the river are shown on Figure 35. River sampling data are summarized in Tables 2 and 3 for a period of record preceding operation of the Supplemental Pumping Station and for the period of operation, respectively.

A comparison of maximum and minimum concentrations of dissolved oxygen and BOD_5 in the river by months is presented as Figures 36 and 37, respectively. These data indicate that dissolved oxygen levels were maintained at or above those for the period of record for stations downstream of the Wastewater Treatment Plant. Likewise, the concentration of 5-day biochemical oxygen demand during the period of operation is lower than that during the period of record downstream of the plant.

A record of the loadings on the Wastewater Treatment Plant is presented in Table 4. This table covers not only the period of operation of the Supplemental Pumping Station, but the nine-month period immediately preceding. The tabulation shows that during that nine-month period, the Waste-

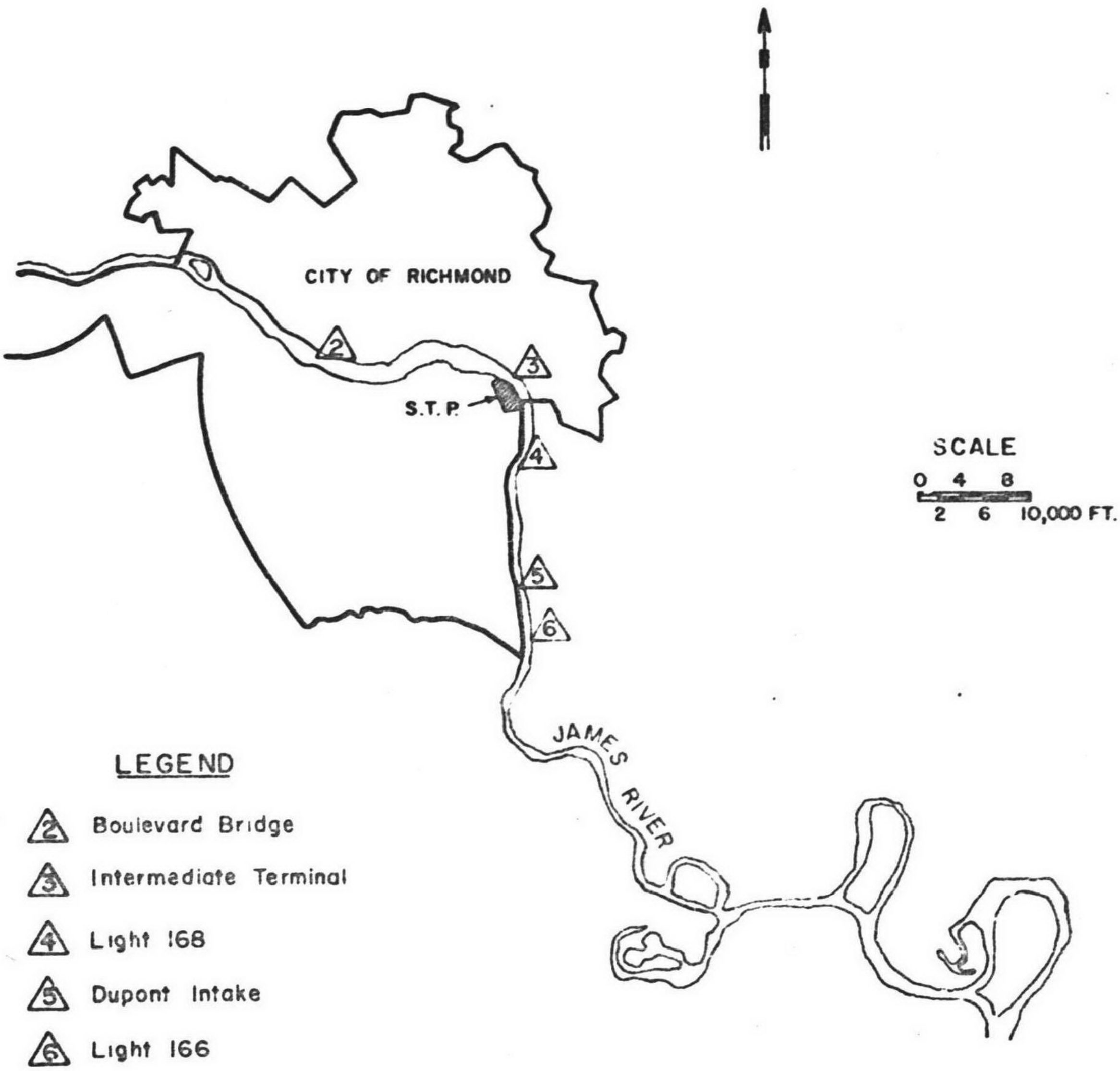


FIGURE 35

RIVER SAMPLING STATIONS

TABLE 2

RICHMOND, VIRGINIA

River Sampling Data
July, 1963-June, 1969

Month	Station 2		Station 3		Station 4		Station 5		Station 6	
	DO % Sat	BOD_5 mg/l	DO % Sat	BOD_5 mg/l	DO % Sat	BOD_5 mg/l	DO % Sat	BOD_5 mg/l	DO % Sat	BOD_5 mg/l
Jan.	99	3.2	99	3.5	98	4.7	97	4.8	96	5.1
Feb.	97	2.5	99	3.6	99	4.9	99	4.1	98	3.7
March	96	2.5	97	2.5	99	3.5	98	3.6	97	3.6
April	96	3.1	93	3.7	89	3.7	84	3.9	83	4.3
May	93	2.7	91	2.9	83	4.3	75	4.4	75	3.9
June	94	1.9	84	3.4	62	4.6	54	4.2	51	4.0
July	91	2.2	63	3.5	32	5.3	22	5.6	27	6.1
Aug.	89	2.6	65	3.7	27	6.6	18	6.4	27	8.1
Sept.	87	2.1	65	3.5	19	8.2	14	7.2	15	7.5
Oct.	91	2.3	87	3.5	59	5.7	61	5.4	56	5.5
Nov.	96	2.5	92	3.4	76	6.9	60	6.0	61	4.8
Dec.	97	2.3	98	3.6	97	5.2	96	5.4	93	5.2
Aver.	94	2.5	86	3.4	70	5.3	65	5.1	65	5.2

TABLE 3

RICHMOND, VIRGINIA

River Sampling Data
February, 1972- December, 1972

Month	Station 2		Station 3		Station 4		Station 5		Station 6	
	DO % Sat	BOD_5 mg/l	DO % Sat	BOD_5 mg/l	DO % Sat	BOD_5 mg/l	DO % Sat	BOD_5 mg/l	DO % Sat	BOD_5 mg/l
Feb.	56	1.8	97	1.3	94	1.9	94	1.9	95	3.1
March	93	1.7	97	0.4	98	2.0	93	2.1	98	0.9
April	69	1.3	87	1.7	90	2.3	84	2.8	94	2.0
May	78	1.2	88	2.1	90	2.2	92	3.0	89	2.2
June	-	-	-	-	-	-	-	-	-	-
July	75	3.2	100	1.0	100	3.0	92	2.4	88	3.4
Aug.	73	5.7	98	1.7	95	0.9	98	2.0	94	2.4
Sept.	76	3.7	97	4.8	80	4.6	74	4.1	80	3.2
Oct.	88	5.1	71	2.7	96	1.0	91	2.6	81	6.6
Nov.	78	1.2	84	1.6	83	1.0	83	2.4	83	2.6
Dec.	58	1.4	85	0.9	88	1.1	91	1.0	85	1.4
Aver.	74	2.6	90	1.8	91	2.0	89	2.4	89	2.8

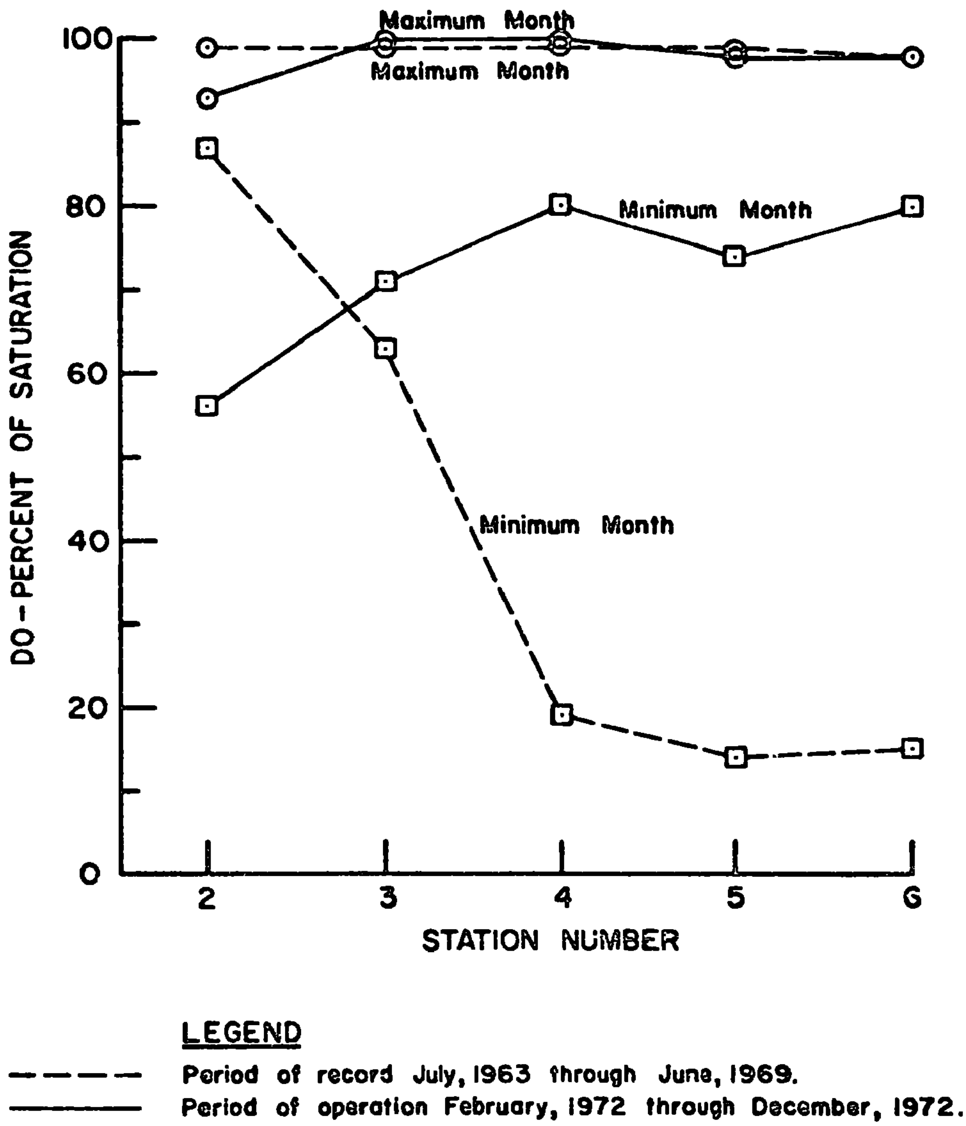


FIGURE 36

JAMES RIVER, DISSOLVED OXYGEN LEVEL

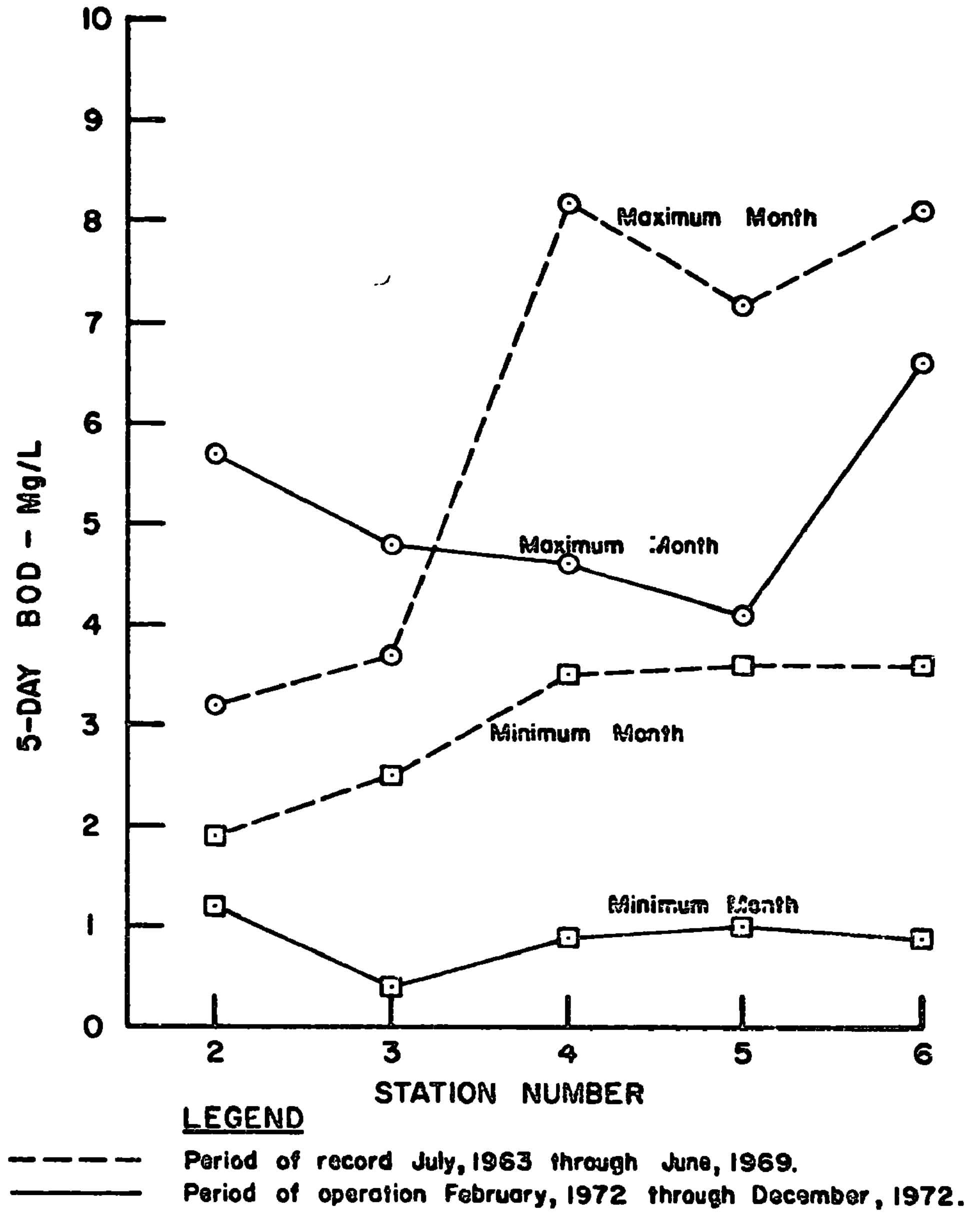


FIGURE 37

JAMES RIVER, BIOCHEMICAL OXYGEN DEMAND

TABLE 4

RICHMOND, VIRGINIA

TREATMENT PLANT LOADINGS

Year	Month	Flow-MGD Ave.	Flow-MGD Max.	Flow-MGD Min.	Suspended Solids Average-mg/l Influent	Suspended Solids Average-mg/l Effluent	5-Day BOD Average-mg/l Influent	5-Day BOD Average-mg/l Effluent	Suspended Solids Load 1000 lbs/day Inf.	Suspended Solids Load 1000 lbs/day Eff.	Suspended Solids Load 1000 lbs/mo Inf.	Suspended Solids Load 1000 lbs/mo Eff.	BOD5 Load 1000 lbs/day Inf.	BOD5 Load 1000 lbs/day Eff.	BOD5 Load 1000 lbs/mo Inf.	BOD5 Load 1000 lbs/mo Eff.
1971	May	41.18	56.24	28.24	161	80	154	95	55.3	27.5	1713	852	52.8	32.6	1635	1010
	June	46.13	61.06	37.76	141	72	101	70	54.3	27.7	1630	831	38.8	27.0	1164	810
	July	37.71	44.60	23.16	136	67	137	97	42.7	21.1	1323	654	43.0	30.5	1331	944
	Aug.	40.67	48.70	35.08	154	76	129	100	52.2	25.8	1620	800	43.8	33.9	1357	1050
	Sept.	40.64	47.18	27.52	146	76	144	113	49.5	25.8	1485	774	48.8	38.3	1464	1150
	Oct.	46.93	59.46	27.68	136	80	104	83	53.2	31.3	1650	971	40.7	32.5	1260	1007
	Nov.	39.0	49.00	23.76	140	79	116	87	45.6	25.7	1368	771	37.7	28.3	1130	849
	Dec.	35.20	47.80	25.38	154	84	124	96	45.2	24.7	1400	765	36.4	28.1	1129	871
1972	Jan.	39.70	46.30	28.40	144	88	140	118	42.6	29.1	1477	902	46.3	39.0	1435	1209
	Ave.	40.00			146	78	128	95	49.5	26.5	1518	813	43.1	32.2	1323	989
	Feb.	49.32	61.32	32.40	122	87	102	109	50.7	36.2	1470	1050	42.4	45.3	1229	1312
	Mar.	44.50	57.50	39.14	128	72	117	96	47.5	26.8	1471	831	43.4	35.6	1345	1103
	Apr.	43.39	55.36	38.80	150	81	149	100	54.3	29.3	1630	879	53.9	36.2	1618	1086
	May	46.40	58.80	36.60	131	72	135	103	50.6	27.9	1570	865	52.2	39.9	1619	1238
	June (1)	49.96	60.50	40.24	133	65	130	91	53.2	26.0	1118	546	52.0	36.4	1091	764
	July (1)	42.6*	-	-	162	72	198	131	57.6	25.6	1210	537	70.6	46.5	1482	976
	Aug.	42.6*	-	-	135	66	150	109	48.0	23.4	1488	725	53.3	38.7	1651	1200
	Sept.	42.6*	-	-	144	74	215	162	51.2	26.3	1536	790	76.5	57.5	2290	1726
	Oct. (2)	42.6*	-	-	115	71	159	112	40.9	25.2	1105	680	56.5	39.8	1525	1075
	Nov.	42.6*	-	-	125	73	140	104	44.4	25.9	1332	777	49.7	37.0	1490	1110
	Dec.	42.6*	-	-	101	61	116	83	35.9	21.7	1112	672	41.2	29.5	1275	915
	Ave.	44.33			131	72	146	109	48.6	26.8	1367	759	53.8	40.2	1510	1137

(1) Figures do not include estimated loadings during the flood of June 23 - July 4
(2) Figures do not include estimated loadings during the flood of October 6-9
* Flow based on average of the previous 418 days

water Treatment Plant received an average monthly flow of 40.80 mgd, 1,518,000 pounds of suspended solids monthly and 1,323,000 pounds of BOD_5 monthly. During the operation of the Supplemental Pumping Station, and not including the periods of shutdown caused by flooding, the plant received an average monthly flow of 44.33 mgd, 1,367,000 pounds of suspended solids monthly and 1,510,000 pounds of BOD_5 monthly.

The effluent for the nine months prior to operation of the Supplemental Pumping Station average 813,000 pounds per month of suspended solids and 989,000 pounds of BOD_5 per month. During operation, not including shutdowns, the effluent averaged 759,000 pounds of suspended solids per month and 1,137,000 pounds of BOD_5 per month. The influent and effluent loadings of flow handled by the treatment plant are shown on Figure 38 (Suspended Solids) and Figure 39 (BOD_5).

Prior to the operation of the Supplemental Pumping Station, the Wastewater Treatment Plant removed approximately 46 percent of the suspended solids and 25 percent of the BOD_5. During operation of the Supplemental Pumping Station, the plant removed approximately 45 percent of the suspended solids and 25 percent of the BOD_5, which indicates the plant continued to function at the same level of efficiency.

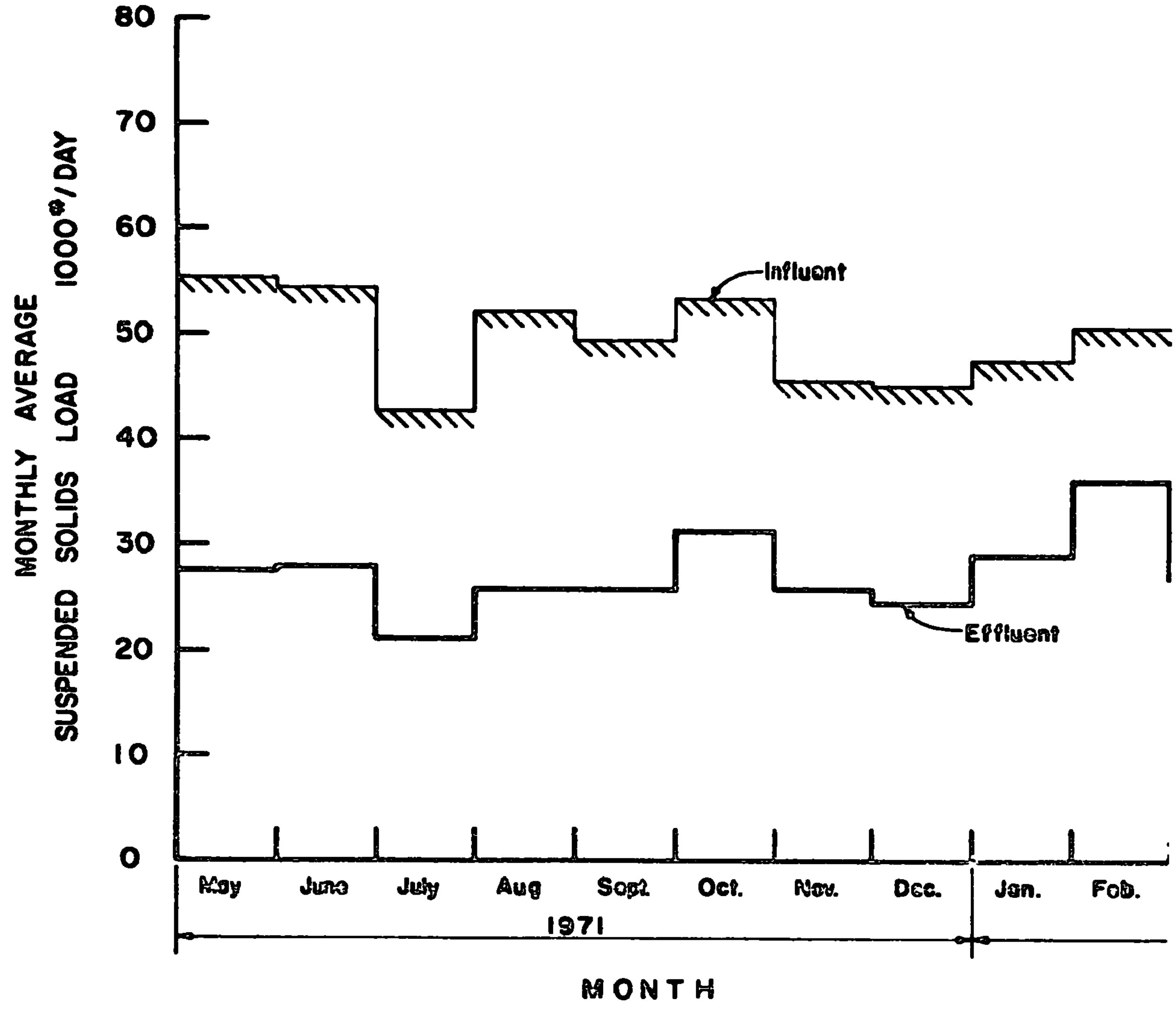
The floods which caused shutdowns of the Supplemental Pumping Station allowed the following estimated suspended solids and BOD loads to enter the river:

Flood	Est. Load-1000's of Lbs. Suspended Solids	BOD_5
June-July, 1972	1,000	1,107
October, 1972	164	226
Total	1,164	1,333

The operation of the Supplemental Pumping Station reduced the load on the James River, over the entire period of operation, a total of 6,630,000 pounds of suspended solids and 4,110,000 pounds of BOD_5.

The James River flows, average, maximum and minimum, are tabulated for the period January, 1958 through December, 1972 and are shown in Table 5. The average monthly flows for 1972, based on preliminary data from the Virginia State Water Control Board are as follows:

Month	Average Monthly Flow (CFS)
January	6,180
February	18,295
March	10,180
April	9,492
May	13,036
June	30,906
July	11,302
August	7,859
September	2,486


80
70
60
50
40
30
20
10
0
MONTHLY AVERAGE
SUSPENDED SOLIDS LOAD 1000#/DAY
Influent
Effluent
May
June
July
Aug
Sept
Oct.
Nov.
Dec.
Jan.
Feb.
1971
MONTH

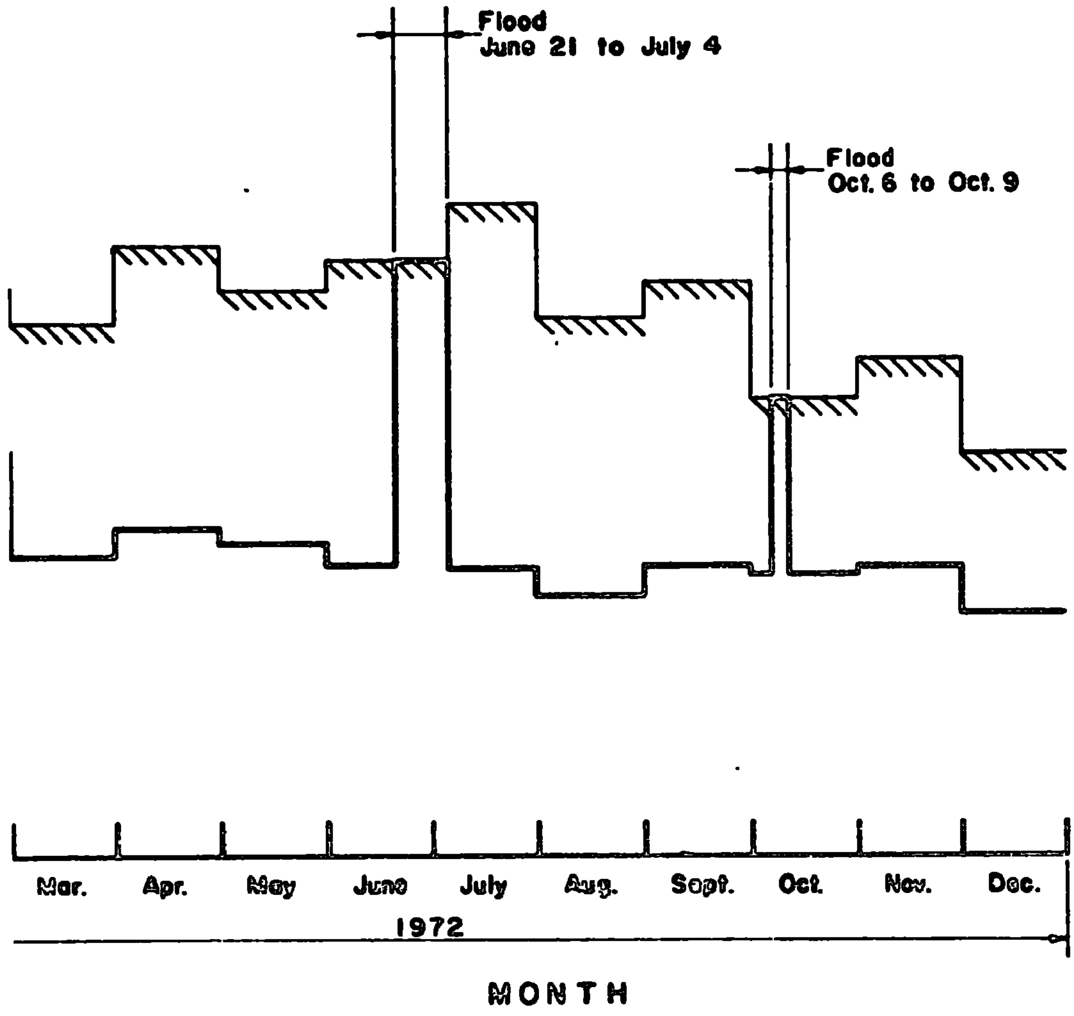
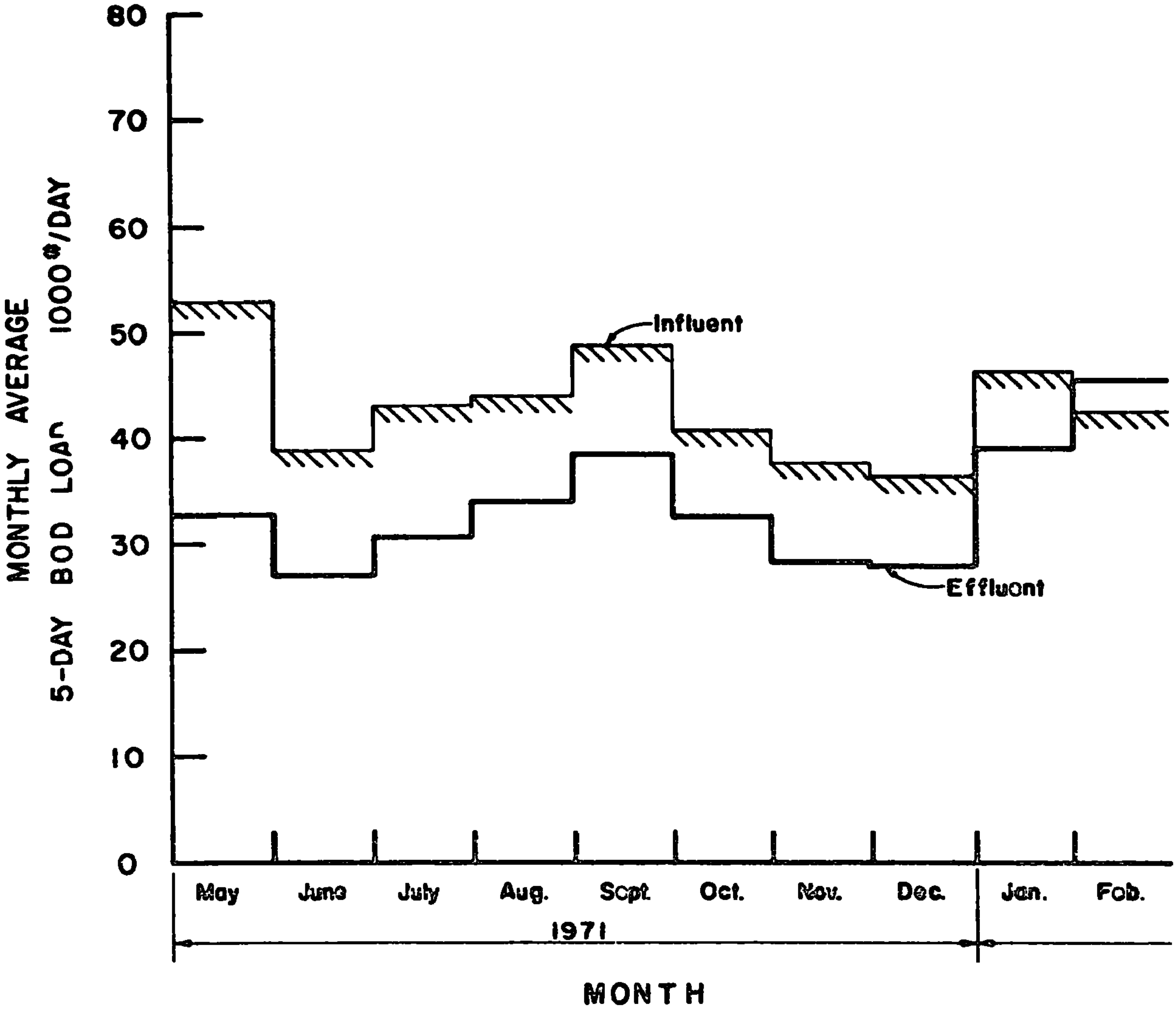


FIGURE 38

WASTEWATER TREATMENT PLANT
INFLUENT AND EFFLUENT LOADINGS
SUSPENDED SOLIDS



80
70
60
50
40
30
20
10
0
MONTHLY AVERAGE
5-DAY BOD LOAD 1000#/DAY
Influent
Effluent
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
1971
MONTH

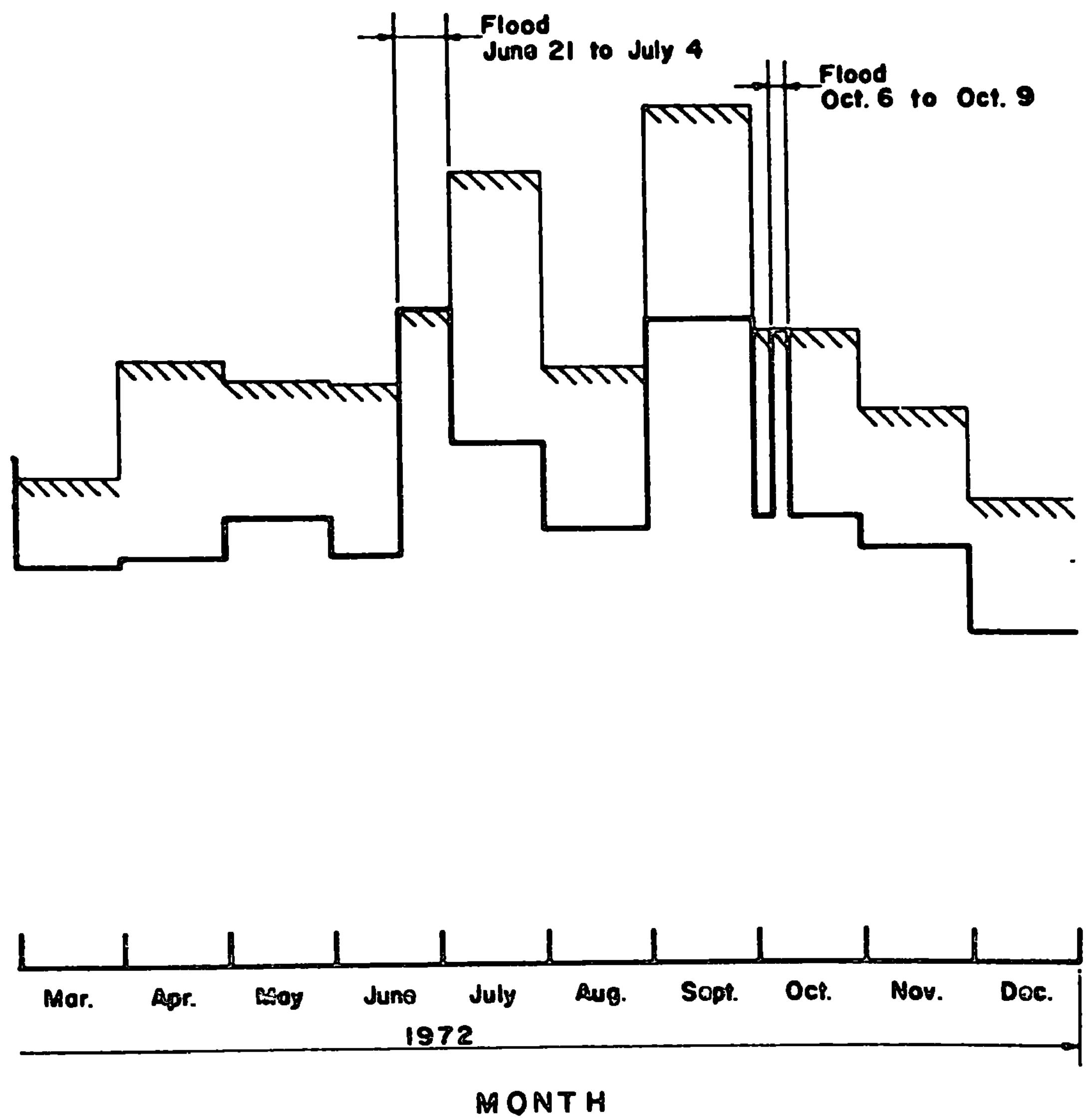


FIGURE 39

WASTEWATER TREATMENT PLANT
INFLUENT AND EFFLUENT LOADINGS
BIOCHEMICAL OXYGEN DEMAND

TABLE 5

RICHMOND, VIRGINIA

James River Flow
January, 1958 through December, 1972

Month	Average Monthly Flow-CFS	Minimum Monthly Flow-CFS	Maximum Monthly Flow-CFS	Range: Max. Minus Min. - CFS
Jan.	7,301	2,903	22,803	19,900
Feb.	10,511	2,957	28,672	25,715
Mar.	12,383	5,117	40,145	35,028
Apr.	9,490	4,466	25,323	20,857
May	7,159	2,887	18,905	16,018
June	5,752	1,184	30,906	29,722
July	2,402	648	11,302	10,654
Aug.	3,413	405	21,710	21,305
Sept.	1,416	202	4,960	4,758
Oct.	4,171	330	18,700	18,370
Nov.	4,507	1,084	19,710	18,626
Dec.	6,455	2,029	20,132	18,103

October	18,700
November	19,710
December	20,132

Comparison of the 14-year average in Table 5 with the above figures for 1972 shows that all months in 1972, except January and March, were greater than the average, most being significantly greater.

The combination of higher than normal river flows and continuation of normal treatment processes resulted in an improved water quality of the James River, even with loadings occasioned by the two floods during the project.

B. The Design

The provision of a steel sheeted structure for the Supplemental Pumping Station proved to be a practical method of construction. Steel sheeting was driven to rock and area inside the sheeting was excavated while the walers were being driven down. Difficulty was experienced in placing the lower walers because the sheeting had drifted in toward the center. Another method of construction which might have lessened the difficulties would be one in which the sheeting and walers were driven together and in which the excavation proceeded with the driving. The construction could then proceed by the sequence of driving, excavating, and placing walers.

While the ground water conditions encountered at the Treatment Plant site are relatively high, it was not necessary to weld the joints of the steel sheeting, however leakage proved objectionable in the steel sheeting separating the wet well and dry well. The Contractor welded the seams of this separation wall between El. -2.5 and El. 6.0. After the June, 1972 flood, the City, under their Annual Welding Contract, completed welding the joints in this separation wall to ground level. Unfortunately, this additional welding work was not completed prior to the October, 1972 flood and consequently, the dry well again flooded. Construction of this type has also indicated the need for a sump pump of greater capacity than that which would be normally provided.

The variable speed control of the pumps appeared to be a good system, but not without difficulties. The system required a time delay circuit to allow the lead and lag pumps to change speeds more smoothly, and adjustments proved very difficult except under low flow conditions. At low speeds the pump controls tended to "hunt" over a 20-30 rpm range.

The air hose to the bubbler control tube was not strong enough and ruptured after about one month of operation.

The pumps and motors operated satisfactorily throughout the project and appeared to be suitable for this type of service.

The electrical system was revised to eliminate the danger from 50 feet of 2400 volt conduit inside the structure ahead of the breaker. The transformers at the substation had trouble with overheating and plugging of the vents in the oil system.

The bar screen platform in the wet well had openings in the north and south ends which allowed large objects to get into the pumps during high flow periods. The apparent solution, which was undertaken, was to provide a "screen" at these openings.

The temporary bulkhead at the South Junction Chamber was a successful design. The bulkheading of a chamber which was not originally designed for the loads appears feasible. The novelty of this bulkhead is also apparent in that it can be installed, operated and removed. Should plant operations require, the bulkhead could be reinstalled.

The removable roof panels as designed are probably acceptable for relatively continuous operation, but are not suitable for emergency equipment removal. For emergency equipment removal, the panels should be designed to be readily removable.

C. The Construction

Due to the restricted area, the Contractor elected to drive the sheet piling for the Supplemental Pumping Station without excavating. This method was successful, but did prove to be time-consumming. The elevation of rock was found to be lower than estimated and this caused some problems since the Contractor had ordered sheeting in "exact" lengths. Additional sheeting had to be ordered and welded on to the driven sheeting.

The method of driving without excavation probably contributed to the sheeting drift toward the center and caused difficulty in setting the bottom waler.

The existing 72-inch sewer and concrete cradle was found to have been built differently from the Plans. There was a misalignment of the sewer, probably due to a ledge of rock. The sewer was built around the rock ledge and the concrete cradle was incomplete.

Construction was generally delayed by slow progress on the pile driving and excavation, the availability of corner sheeting, structural steel, control circuitry, and reworking of controls.

The modifications of the South Junction Chmmber proceeded slowly and intermittently with small crews, but was ready to receive the bulkhead when the Pumping Station was ready for operation. Only one day was required to make the necessary modifications to the bulkhead to accommodate the different size opening. The installation went smoothly and the bulkhead required no further modifications.

The final completion of the new Grit Removal Facilities was delayed twice by flooding. The floods of both June and October, 1972, occured at approximately the time when construction was complete and connection was to be made. When the grit facilities were finally brought on line, the Supplemental Pumping Station was on standby service and adjustments were made both at the grit chamber and the Main Pumping Station. When final adjustments were completed the temporary bulkhead was removed and the Supplemental Pumping Station deactivated. The Supplemental Pumping Station can be reactivated should conditions at the Wastewater Treatment Plant require.

D. Operations

The operation of the Supplemental Pumping Station demonstrated that a constant wet well level was very difficult to achieve and the fluctuations caused the lead and lag pump operation to be generally troublesome. Manual adjustment and operation of the station were often required. If a pump were shut off without bringing down the speed, the sewage in the discharge line would rush back and quickly raise the wet well.

Cleaning of the bar screen was difficult because of the large fluctuations in the wet well and especially difficult during periods of high flows when the sidewalk platform was submerged. During flood conditions, the bar screen became clogged with debris and caused the pumps to "hunt" for an operating range, caused debris to flow over the platform and down through the openings.

The pump control electrolyte reservoir level required regular attention and when the level became too low, the pump speeds would vary erratically over a range of 40-50 rpm. Also, it was necessary to enclose the electrolyte controls to protect them from freezing during cold weather periods.

The operation of the temporary bulkhead in the South Junction Chamber demonstrates that with careful preparation, design and fabrication a device can be provided which can divert flow without shutdown. Provision of such a device should also consider the greater expense required to insure a workable solution.

The Supplemental Pumping Station was a generally reliable facility, despite operational problems associated with full automatic operation. Adjustments of the station controls proved difficult under "on-line" conditions and the system was often operated manually. The speed of construction, closely followed by operation probably did not allow an adequate period of training and orientation for the operating personnel. Consequently, problems did develop due to inappropriate action or faultly adjustments.

The Supplemental Pumping Station is now expected to remain available for standby service. During the near future, repairs to flood damage will be made and the station restored to pre-flood condition with modifications to the superstructure roof. The present plan is to operate the station weekly to insure its continued reliability.

SECTION VIII

REFERENCES

1. City of Richmond, Virginia. Agreement between City and Virginia Electric and Power Company, dated March 22, 1971, to construct Supplemental Pumping Station Electrical Substation.

2. City of Richmond, Virginia. Division X - Grit Removal Facilities. Change Order No. 7, dated April 17, 1970; Change Order No. 9, dated October 10, 1970.

3. City of Richmond, Virginia. Divisions XII and XIII - Secondary Treatment Facilities - Phase 3. Change Order No. 2, dated September 2, 1970; Change Orders Nos. 3 and 4, dated October 10, 1970; Change Order No. 5, dated October 21, 1970.

4. City of Richmond, Virginia. Supplemental Pumping Station - Furnishing Pumping Equipment. Change Order No. 1, dated May 19, 1971.

5. City of Richmond, Virginia. Supplemental Pumping Station. Daily Operating Records and Operators' Logs.

6. City of Richmond, Virginia. Supplemental Pumping Station. Operating Charts for Discharge Pressure - Pumping Unit No. 1.

7. City of Richmond, Virginia. Supplemental Pumping Station. Operating Charts for Discharge Pressure - Pumping Unit No. 2.

8. City of Richmond, Virginia. Supplemental Pumping Station. Operating Charts - RPM - Pumping Unit No. 1.

9. City of Richmond, Virginia. Supplemental Pumping Station. Operating Charts - RPM - Pumping Unit No. 2.

10. City of Richmond, Virginia. Supplemental Pumping Station. Operating Charts - Suction Pressure - Pumping Unit No. 1.

11. City of Richmond, Virginia. Supplemental Pumping Station. Operating Charts - Suction Pressure - Pumping Unit No. 2.

12. City of Richmond, Virginia. Wastewater Treatment Plant. Daily Operating Records.

13. City of Richmond, Virginia. Weekly James River Analysis Report. (Six sampling points in James River)

14. Greeley and Hansen, Engineers, Chicago, Illinois. Plans and Specifications dated April, 1970, entitled "Supplemental Pumping Station - Furnishing Pumping Equipment."

15. Greeley and Hansen, Engineers, Chicago, Illinois. Plans and Specifications dated August, 1970, entitled "Supplemental Pumping Station and Appurtenances - Structures."

16. Jordan, C. L., Resident Construction Engineer. Notes on Construction and Operation of the Supplemental Pumping Station.

17. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service. Climatological Data for Byrd Field Station, Richmond, Virginia.