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	Engineering and Design GENERAL PRINCIPLES OF PUMPING STATION DESIGN AND LAYOUT	
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DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

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No. 1110-2-3102

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Engineering and Design
GENERAL PRINCIPLES OF PUMPING STATION DESIGN AND LAYOUT

1. Purpose. This manual provides information and criteria pertinent to the design and layout of civil works flood control pumping stations. Elements discussed include various sump designs and discharge arrangements, station type and layout requirements, and environmental and power requirements.

2. Applicability. This manual applies to all HQUSACE elements, major subordinate commands, districts, laboratories, and field operating activities having civil works responsibilities.

FOR THE COMMANDER:

R. C. JOHNS
Colonel, Corps of Engineers
Chief of Staff

This manual combines and supersedes EM 1110-2-3101, dated 3 December 1962, and EM 1110-2-3102, dated 3 December 1962.

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Chapter 1
Introduction

1-1. Purpose and Scope

This manual provides guidance for the design and layout of civil works pumping stations used for removal of interior drainage from areas protected by local flood protection works and for water supply. The discussion presented in this manual is general in nature. The development of detailed design criteria is presented in other manuals referenced herein. This manual is for the guidance of Corps of Engineers personnel engaged in the design of flood protection projects.

1-2. Applicability

This manual applies to all HQUSACE elements, major subordinate commands, districts, laboratories, and field operating activities having civil works responsibilities.

1-3. References

a. CFR, Section 208-10, Title 33

b. **ER 1110-2-109**
Hydroelectric Design Center

c. **ER 1110-2-401**
Operation, Maintenance, Repair, Replacement, and Rehabilitation Manual For Projects and Separable Elements Managed by Project Sponsors

d. **ER 1165-2-131**
Local Cooperation Agreements for New Start Construction Projects

e. **EM 385-1-1**
Safety and Health Requirements Manual

f. **EM 1110-2-1413**
Hydrologic Analysis of Interior Areas

g. **EM 1110-2-1913**
Design and Construction of Levees

h. **EM 1110-2-3104**
Structural and Architectural Design of Pumping Stations

i. **EM 1110-2-3105**
Mechanical and Electrical Design of Pumping Stations

j. [1]**NFPA 10**
Standard for Portable Fire Extinguishers

k. [1]**NFPA 37**
Stationary Combustion Engines and Gas Turbines

l. [1]**NFPA 101**
Life Safety Code

1-4. Plates

Plates 1 through 12 in Appendix A show different types of pumping stations constructed by the Corps of Engineers. A short description of each pumping station is also provided.

1-5. General

a. Dependability. Pumping stations are one of the more vulnerable features of a flood protection project. The failure of a pumping station during a flood could result in considerable damage within the protected area. This would cause the loss of some or all of the benefits that justified construction of the project. Consequently, station dependability must be the primary consideration, during the design and pump selection process.

b. Economics. While the cost of the pumping station is generally but a small percentage of the cost of the entire project, this does not mean that the designer is to proceed without any consideration of cost. Because of the infrequent operation of the majority of local flood protection pumping stations, efficiency can be sacrificed to a certain extent in favor of equipment with a lower first cost. However, higher pump efficiencies can actually lower the installed horsepower requirements and reduce operating costs for large stations that have frequent usage. The extra costs to provide higher efficiency equipment should be studied on a life cycle cost basis over the project life. This economic study should consider both first cost and the cost of operation, maintenance, and replacement of equipment over the project life.

c. Refinements. The equipment selected must be rugged, reliable, and well suited for the required type of service. The pumping station structure should be sized to house and support the equipment. Refinements which make no realistic contribution to usability or dependability

[1]Available from National Fire Protection Association, P.O. Box 9146, Quincy, MA 02269.

should be strictly avoided. Architectural appearance will not be a governing criterion except in highly developed areas where concessions in regard to exterior treatment may be made as discussed in EM 1110-2-3104.

d. Large stations. In the design of some stations an unusual combination of conditions may be encountered which will require special treatment. This will frequently be the case for exceptionally large stations. However, the fundamental principles, criteria, and policies provided herein are applicable to all stations. Stations having a capacity of 30 cu m/sec (1,060 cu ft/sec) or larger will be engineered by the Hydroelectric Design Center (HDC) in accordance with ER 1110-2-109.

1-6. Local Cooperation

a. General. Project cooperation agreements (PCAs) are prepared by the project management office in accordance with ER 1165-2-131. Engineers responsible for the preliminary design and layout of the pumping facility should coordinate any special design features that may affect the local sponsor's costs with the project manager.

b. Maintenance and operation. A project's Operation and maintenance manual will outline the responsibilities of the project sponsor for the operation, maintenance, repair, replacement, and rehabilitaion (OMRR&R) of all project features. Instructions for the preparation of operation and maintenance manuals are provided in ER 1110-2-401. Development of the pumping station feature of the manual is contained in EM 1110-2-3105.

Chapter 2
Environmental Requirements

2-1. General

The planning, design, construction, and operation of pumping stations should be accomplished with full consideration for the project's environmental requirements. Many of these requirements are dictated by Federal or state statutes, by local sponsor's desires, or by USACE policy. In any case, studies of pumping station features should be undertaken to identify potential impacts and to define environmental objectives and constraints.

2-2. Environmental Impacts

Pumping stations affect the hydrology and water quality of both the receiving and supplying water bodies. The changed hydrologic and water quality conditions often affect other environmental parameters. The following list contains some of the potential adverse environmental impacts of a pumping station feature:

a. Reduced dissolved oxygen.

b. Increased temperature.

c. Increased turbidity and suspended solids.

d. Lost habitat (riparian and aquatic).

e. Change in hydrology and hydraulics.

f. Noise generated by prime mover (diesel versus electric).

g. Aesthetics.

h. Waste fuel oil and lubricating oil and greases.

2-3. Environmental Objectives

A pumping station can and should have negligible adverse environmental impacts. Through proper planning, design, construction, and operation, many of the adverse impacts listed above can be avoided or minimized. Remaining impacts should be mitigated and environmental enhancement addressed. The following steps should be taken to better ensure satisfactory compliance with the environmental objectives of pumping station projects:

a. Identify all environmental objectives and constraints, including statutory and policy requirements and sponsor's desires.

b. Identify all potential environmental impacts, both adverse and beneficial.

c. Incorporate design, construction, or operation features that avoid or minimize adverse impacts.

d. Quantify unavoidable adverse impacts and incorporate appropriate mitigative features.

e. Incorporate environmental enhancement features as required to address the sponsor's desires (sponsor funded).

Chapter 3
Electric Power Supply

3-1. General

a. Studies. When the power requirements for the pumping station have been tentatively established, the adequacy of the intended source of electric power and any limitations of that source must be ascertained before proceeding with station design. The design investigations should disclose:

(1) Maximum available power.

(2) Capacities and location of existing transmission lines, distribution lines, and substations which may be involved in the supply of power to the pumping station.

(3) Voltage regulation characteristics.

(4) The power company's maximum permissible motor in-rush current limitations and short circuit characteristics.

b. Adequacy. The responsibility for the supply of electric energy required for the operation of the pumping stations after completion of the project rests with the local sponsor. Any extension of existing power transmission facilities required to make this energy available at the pumping station site is a construction feature and the responsibility of the Government. In many instances, it will be necessary for the Government to participate in the preliminary negotiations with the utility supplying power in order to ensure that the completed project will have, at minimum rates, an adequate power supply of the proper characteristics. Where feasible, the contract should be made between the local interests and the utility supplier. However, there will be many cases where it will be more advantageous for the Government to enter into a contract which provides for both the extension of power facilities and supply of electric service. In those cases the Government should enter into such a contract with the understanding by all parties that the costs of energy will be assumed by the local interest upon completion of the project, in accordance with OMRR&R responsibilities.

c. Reliability. Power source reliability will be indicated by the number, size, type, and location of generating facilities, and of interconnections with other systems. In this respect, consideration should be given to the short, infrequent periods of operation of the pumping station and to the ability of local governments to direct power distribution under emergency conditions. Owner's operation records of the supply lines to which connections are contemplated are important aids in determining the extent and nature of construction necessary for reliable supply. Factors affecting the reliability of the supply connection between the power source and the pumping station are:

(1) Length, location, and type of construction of the connection.

(2) Location of the point of connection to a different source.

(3) Appropriate switching equipment between the connection and supply circuits.

d. Power rates. In view of the type of operation and the public service these stations render to the community, it has been the practice to request the public utility supplying power to give special rate considerations. These considerations include the waiver of some or all demand and standby charges, and the charging for only the actual energy used. Power rates should be negotiated on the basis of turning over maintenance and repair to the power company for all the power lines and the substation necessary to operate the pumping station. Hydrology studies are a good tool to estimate the amount of pumping required, power usage, and resulting rate structure. Local interests should be asked to participate in the power supply studies.

3-2. Power Supply

a. Construction required. All facilities and construction necessary to supply the electric power required to operate the pumping stations will be provided as part of the flood protection project. The cost of these facilities will be included in the project costs. The construction required may vary from the simple overhead service drop at utilization voltage to extensive installations involving transmission lines, switching, and transformer equipment. The power line should be available at the time that the construction contractor needs temporary power to construct the pumping station. Power costs and temporary substation costs incurred during construction should be borne by the pumping station contractor. The substation should be located and constructed so that access is available to the electric utility for maintenance and repair.

b. Power for lighting and auxiliary services. A continuous electric supply for lighting, heating devices, and miscellaneous control or protective devices is required. The power supply for these auxiliary services may be separate from the main power supply to eliminate the necessity to have continuous energizing of main transformers and switchgear.

c. Emergency power supply facilities. In general, flood protection pumping stations should be considered emergency facilities. Equipment and power supply should be selected primarily on the basis of reliability under emergency conditions. Additional emergency or standby power supply facilities should not be provided unless the power supply is considered unreliable.

Chapter 4
Station Design

4-1. Station Capacity

Pumping station capacity requirements are normally determined by the hydraulics engineer in accordance with EM 1110-2-1413. This manual provides the basis for establishing pumping requirements for the maximum and minimum river stages, and the maximum water stages permissible in the protected area. The latter will be referred to the station location and will establish the maximum allowable water surface elevation in the station sump. The hydraulic data provides the basic information needed for the selection of equipment and, in turn, the layout of the station. In those special instances where an increase in pumping capacity can be definitely expected at some future date, consideration should be given to a station design which facilitates the installation of increased capacity in a manner that will give the greatest overall economy. Alternate studies of pumping stations satisfying the required pumping capacity should be made for all pumping station projects. As a minimum, the studies should include station location, station site layout, all equipment, sizing of pumps, type of operation, and operating and maintenance costs and first costs.

4-2. Station Location

a. General. Experience has shown that a pumping station should be located or sited in such a manner to produce the most direct inflow possible. Any location that produces asymmetrical flow into the pump bays causes problems with circulation, uneven velocity distribution, vortices, and generally poor pump performance. This is true for inflow confined within an inlet channel, sewer, or a large ponding area. Additional engineering studies and/or physical modeling may be required when circumstances exist that prevent recommended station siting. Gravity flow structures, when provided, can be located in an offset position without additional cost and still perform adequately.

b. Line of protection. The location of stations with respect to the line of protection should be selected for safe operation. Construction of the station integral with a concrete floodwall will, in general, minimize the hazard of discharge line failure. On projects with an earth levee or where right-of-way restrictions exist, the station may be located at the landside toe of the levee. More hazardous locations (riverside of protective works) may be considered if a definite operational or economic advantage is presented. Vehicle access to stations at all flood elevations should be carefully considered in station location, and minimum but adequate provision should be made to permit safe operation of service vehicles bringing in equipment during construction and operation and maintenance.

c. Operating floor elevation. The operating floor elevation should reduce the possibility of damage, caused by flooding, to the pumping equipment. This elevation is dependent upon the hydraulics and hydrology criteria, the location, and the physical layout of the pumping station.

(1) When the pumping station is located on the line of protection, the elevation of the operating floor will depend on whether the pumping station is subject to the discharge pool elevations, or is protected by a flood wall or a discharge chamber. When the pumping station is subject to the discharge pool elevations, the operating floor should be no lower than the top of the levee. When the pumping station is protected by a flood wall or a discharge chamber, the operating floor elevation should be located at least 0.3 m (1 ft) above the interior level of design protection.

(2) When the pumping station is not located on the line of protection, the elevation of the operating floor should be at least 0.3 m (1 ft) above the interior level of design protection.

(3) For high, nonpumping water levels, one method to reduce the operating floor elevation is to floodproof the facility. Floodproofing would be achieved by providing watertight doors or bulkheads at all openings. If floodproofing is being considered, the cost and practicality to floodproof the facility should be carefully studied.

4-3. Station Type

a. Floodwater pumping stations. These stations should be of the wet-pit (sump) type employing vertical mixed-flow or axial-flow pumps in practically all cases. These pumping units may also be of the submersible type (Plate 1). Floodwater pumping stations usually pump directly from open storage ponds, ditches, or stormwater sewers. When practical, provision should be made for exclusion of water from the pump sump and for maintaining the sump in a dry condition during inoperative periods. A typical station for pumping water from an extensive open ponding area is shown in Plates 2 and 3. This station is located at the edge of the ponding area, adjacent to the gravity drainage structure discharging through the levee. The station's inlet sump is at an

elevation considerably lower than the gravity flow stream requiring the sump to be pumped dry when the station is not in use. A large pumping station that pumps from an open sump is shown in Plates 4 and 5. A typical stormwater pumping station that pumps from a stormwater sewer is shown in Plates 6 and 7. Occasionally stations will be located over streams or drainage canals and in such instances pumps must be protected from damage by runoff during inoperative periods. Since the liquids pumped by stormwater pumping stations are generally not of a particularly corrosive nature, a wider latitude in selection of materials is permitted.

b. Combination flow pumping stations. Stations in which flows consist of some combination of stormwater and domestic and industrial wastes are characterized by having to pump runoff containing undiluted waste. The possibility of fumes and vapors should be considered when designing the sump ventilation system and electrical features located in the sump. When wastes are combined with stormwater, the need for a smaller pump to handle dry weather flows and runoff from light rains should be provided. This baseflow pump should be a submersible, nonclog pump. The baseflow pump is located in the main sump and equipped so that it can be raised for cleaning or repair, reducing the need for personnel to enter the sump. For stations on sewers having a relatively short time of concentration, it is necessary to place the stormwater pumps in operation within a short time after the start of rainfall. If large sluice gates are used to close the opening between forebay and the main sump, power operation of the gates will be required. Diluted domestic and industrial wastes will be present in the main sump. Protection against corrosive fumes and vapors is a greater problem than in stations handling only stormwater. All sump openings in the superstructure should be sealed airtight.

Chapter 5
Equipment Selection

5-1. Number and Size of Pumps

a. General considerations. A detailed discussion of the selection of pumps, prime movers, electrical equipment, and other miscellaneous auxiliaries is given in EM 1110-2-3105. The design should obtain the desired operations at the lowest possible cost. The cost used to determine the pumping station design should be based on an annualized cost which should consider both first cost, operating and maintenance cost, and cost of equipment replacement over the life of the project. Generally, the lowest cost is obtained with a minimum number of pumps. However, a minimum of two pumps is recommended. Baseflow for combined-flow stations should have sufficient capacity for peak domestic and industrial flows, seepage, and runoff due to light rains.

b. Economic study. The number and resulting size of stormwater pumps must be determined by an economic study. This study should consider the consequences and related costs due to flooding if one pump malfunctions during a flood event. The greater the number of pumps, the smaller the reduction of the total station capacity if one pump malfunctions. This increased protection, however, results in higher equipment, facility, and operation and maintenance costs. The need to reduce the impact if one pump malfunctions will most likely be appropriate in urban areas where a pump failure could cause significant property damage and raise ponding more rapidly to life-threatening depths. The extra costs cannot normally be justified in areas where there are adequate flood warnings or no life threat. Any decision to add more pumps or more capacity to reduce pumping time and/or ponding stage in the event one pump malfunctions must be well justified and the justification well documented. An economist will normally perform the economic study, closely coordinated with the hydraulics and pumping station design engineers associated with the project.

c. Standby capacity.

(1) If seepage flows are more than 30 percent of the total required capacity of the pumping station, the number and capacity of the pumps shall be such that a 100 percent standby pumping capacity is available with failure of any installed pump.

(2) For stations pumping stormwater only or combined flows of stormwater and sanitary sewage, no standby capacity should be provided. Stations located in agricultural or tidal areas where pumping availability is 80 percent of the year, or the interval between operations is insufficient to allow proper maintenance of equipment, standby capacity equal to the largest pumping unit should be provided.

(3) For stations pumping sanitary and industrial sewage only, where one pump is required for the design capacity, a duplicate pump should be provided. Where more than one pump is needed to meet the required capacity, standby capacity equal to the largest pumping unit should be installed.

d. Sump size. The size of the sump may affect the selection of sizes and number of pumps with regard to the minimum desirable operating cycle. For a given sump size, the number and size of pumps should be such that the minimum operating cycle would be 6 min for submersible pumps, 20 min for wet-pit pumps with motor size up to and including 75 kW (100 hp), and 30 min between starts for pumps over 75 kW (100 hp). Pumping units over 375 kW (500 hp) should be started according to data furnished by the motor manufacturer. Where bypasses or variable discharge pumps are to be used, the size of the sump has little effect on the size or number of pumps.

e. Programming. Consideration of all pertinent factors may indicate that pumps of various capacities should be provided, at some installations, so that suitable operation would be obtained with minimum sump size. For such installations, the maximum increment in pumping rates may be made equal to the smallest unit, making it possible to pump at a rate approaching that of the inflow. Programming should not be done when the number of pumps becomes unduly great, or the controls so complicated, resulting in excessive costs and decreased reliability. Experience has indicated that variable speed motors for one or two of the pumps may be more advantageous than programming various size pumps. A note of caution about the use of variable speed drives: variable speed drives complicate pump selection, increase first costs and maintenance costs, require a higher level of technical ability for maintenance, and decrease reliability.

f. Limitations of in-rush demand on transmission system. An investigation should be made to determine whether the maximum pump size is limited by the maximum in-rush demand for pump starting that can be tolerated by existing power facilities. Where the existing power facilities place a limitation on starting demand kVA, pumps having relatively flat input horsepower demand characteristics and adjustable blade pumps or

variable speed pumps should be considered. Engine-driven pumps should also be studied to determine if these are required due to weak power supply conditions. If pumping stations are primarily used during periods of hurricane conditions, it may be required for the pumps to be engine driven and for the station auxiliaries to be supplied with backup power by engine-driven generators.

5-2. Pump Control

a. General. The decision as to the type of control to specify for a flood control pumping station should be based on providing maximum reliability consistent with economic design. In the majority of cases, controls providing for manual start and automatic stop will be the most economical. From the standpoint of reliability, such controls are preferred. The disadvantages of automatic controls include increased complexity due to the additional control equipment, greater cost, and reduction in reliability. However, some installations may find the use of automatic start and stop controls to be an advantage, such as where limited sump capacity and inflow conditions would make manual starting impracticable due to short operating cycles, or where economy is obtained by using pumps of different sizes operating in a predetermined sequence. The control circuits of automatic stations must provide protection against simultaneous starting of all pumping units following a power interruption. Automatic controls are more susceptible to deterioration due to long periods of disuse and will require more frequent inspection and maintenance to keep them in working order. Personnel with the skill and knowledge required for maintenance of automatic control equipment should always be available. Automatic controls must be compared with the justified alternate manual controls. Automatic controls must have a manual control backup.

b. Automatic operation. CFR 208-10 requires that "competent operators shall be on duty at pumping plants whenever it appears that necessity for pump operation is imminent." This statement basically eliminates all automatic and remote pump operation. However, considering the reliable automatic features available and the type of operation required at some facilities, it is recognized that this requirement is not always practicable or justified. Any Corps office considering the use of automatic or remote features should request and fully justify a deviation to the stated requirement. This request for deviation should be submitted to higher authority early in the design phase of the project.

Chapter 6
Sump Design

6-1. General

Rectangular wet pit and the formed suction intake (FSI) are the two basic sump types most commonly used in civil works pumping stations.

a. Rectangular wet pit. In the past, the rectangular wet-pit sump with the conventional pump bell-mouth inlet was the most common type used. Experience has shown, however, that the sump's hydraulic performance is very sensitive to inflow conditions, sump design, and pump operation. Appendix B, Chart B-2, of EM 1110-2-3105 provides sump design guidance.

b. FSI. The FSI was developed in the early 1990's by the WES Hydraulics Laboratory. The FSI has demonstrated the ability to improve the poor hydraulic sump performance sometimes experienced with the rectangular wet-pit sump. Detailed design guidance for the FSI is provided in Appendix I of EM 1110-2-3105. A pump station equipped with an FSI is shown in Plates 8 and 9.

6-2. Size and Capacity Determination

a. Sump levels. Maximum water surface elevation in the sump of stations pumping from sewers will be fixed by project damage elevation, by the hydraulic gradient between the protected area and the pumping station, and by the condition of the particular sewer. For stations pumping from ponding areas, the maximum water surface elevation of the sump will be fixed by the maximum permissible ponding elevation. For sewers subject to structural damage from fluctuating water pressure, such as old brick sewers in questionable condition, and sewers which are inadequate to pass the design storm runoff, the maximum sump operating level should be restricted to the elevation of the crown of the sewer at the point of entrance to the sump. For a well-designed and well-constructed sewer, the maximum sump operating level may fall above the crown of the sewer, subject to consideration of the level of the hydraulic gradient with respect to "no damage" level along the sewer. The station-operating floor elevation should be no lower than 1 ft above the maximum water surface elevation in the sump. The sump shall be kept dry either by gravity drainage or by sump pump(s). If the period of gravity drainage occurs less than 50 percent of the nonpumping period, then sump pumps should be provided to dewater the station's sump. The minimum water surface elevation in the sump is determined by the hydraulic and protection requirements of the protected area and economic considerations. This minimum sump elevation affects the station design and pumping equipment characteristics.

b. Minimum sump area. Minimum horizontal sump area will be that required to permit adequate spacing of pumps and intake systems to provide adequate space for installation of discharge and suction lines and associated equipment and flows to the pumps. Sump area based on these requirements normally will be adequate unless it is found desirable to increase the horizontal area of the sump either to provide more sump storage volume to obtain acceptable minimum pump operating cycles, or to alleviate surges caused by pump shutdown in the sump and connecting sewers.

c. Determination of sump dimensions. The dimensions and general layout of the sump must fulfill a number of requirements. Primarily, the selected design must provide adequate horizontal and vertical clearance and adequate approach conditions for the pumps to be used. Important layout and dimensional requirements for satisfactory pump performance are as follows:

(1) Horizontal clearances for rectangular wet-pit sumps are generally satisfied if the distance between centerlines of adjacent pumps is equal to the sum of the suction bell diameters (plus the thickness of the divider wall), and if the centerline of each pump is a least one suction bell diameter away from the nearest sump side wall and three-fourths of a suction bell diameter from the rear wall. The use of suction umbrellas does not change the above clearances. In general, the diameter of a propeller pump's suction bell (no umbrella) is around 1.5 to 1.6 times the nozzle inlet diameter. (Appendix B, Chart B-2, of EM 1110-2-3105 may be used for these dimensions.)

(2) The principal factors involved in the determination of submergence and vertical clearance requirements are cavitation limits and the means to preclude the formation of sustained vortices. Chart B-2, referenced above, should be followed for these dimensions.

(3) Cavitation can be reasonably predicted from the computational procedure in Appendix B of EM 1110-2-3105. This procedure computes the required submergence based on test results of pumps at Corps pumping stations. A submergence allowance is used to obtain greater submergence for pumping stations with long periods of operation. The impeller should always be completely submerged at the start of pumping.

(4) Vortex formation can be minimized by controlling the flow conditions into the sump and to the pump. Station layout dimensions and ratios provided in Appendix B of EM 1110-2-3105 along with straight inflow to the station intake should eliminate or reduce the intensity of vortexes. If the station cannot be laid out to these dimensions and straight inflow does not occur, then either a sump model test should be considered or the FSI incorporated into the design. The FSI has demonstrated the ability to nearly eliminate vortexing at the pump.

d. Sump layout.

(1) The best flow conditions are obtained when the water approaches the pump from all directions with as uniform a velocity as possible and with minimum disturbance from the flow toward other units. The placing of the sump intake to provide as near equal flow distances as possible to the pumps is a good start toward satisfactory sump flow conditions.

(2) Whenever station layout permits, an intake gate should be provided in front of each pump. Velocity through intake gates must be coordinated with the sump drawdown or operating range. In general, the velocity through intake gates should be as low as possible provided no special requirements or excessive increased costs are involved. In no case should the velocity through the gate be greater than 1.5 m/sec (5 fps). Abrupt changes in direction and velocity of flow should be avoided.

(3) Sump design and layout will be based on established Corps guidance. However, if the pump manufacturer disagrees with the Corps' design and proves, through model testing, a better design, then the contractor's design should be used and the contractor held responsible for the sump design.

e. Sump capacity.

(1) In addition to the above-mentioned requirements for satisfactory pump operation, the station design should include a determination of the water volume between maximum and minimum operating elevations that will permit acceptable minimum pump operating cycles. This water volume would include the capacity of the sump, trash rack chamber, interconnecting sewer, or ponding area. Sufficient storage is provided between the pump's starting and stopping elevations when the starting of any one pump will not be required more often than once in 15 min or a cycle as recommended by the motor manufacturer. An inflow rate equal to one-half of the pumping rate of the pump should be assumed, as this inflow will cause the most frequent number of repeated starts and stops of the pump. Storage required above the stop elevation to ensure a minimum interval as indicated above between successive starts of a given pump is usually not possible. Since the maximum sump operating level is usually fixed by the project damage elevation or other considerations, any required increase in sump capacity can be accomplished only by lowering the sump floor. A gain in sump capacity by lowering the sump floor is usually attended by increased pumping power requirements. An increase in sump area will probably cause adverse flow to pumps and therefore cannot be used. A variable speed pump drive should be considered since on-off cycles and surges when the unit is stopped can be eliminated by its use.

(2) The use of bypasses gains equivalent sump capacity during periods of pump operation with small inflows and accomplishes that function by decreasing the net effective discharge of pumps operating. Bypasses should be considered where space and structural requirements cannot be changed and sump capacity is inadequate to: prevent excessively frequent starting of pumps, particularly where failure of one pump of a group operated on programmed control is a possibility; compensate for a lag in the inflow from a sewer; and prevent surges in sewers and sumps which would be caused by rapid lowering and then raising of sump levels.

(3) Bypasses may be located so as to permit return flow from riverside discharge chambers into the sump, or direct flow from a pump discharge line into the sump at a point between the pump and its discharge. With the former arrangement, the bypass is effective regardless of which pump is operated. The latter arrangement is used where pump discharge lines pass over levees and require a bypass on each pump or a number of pumps to ensure satisfactory bypass capacity when any pump is out of service.

(4) Where a single bypass from the discharge chamber to the sump is to be installed, its capacity at minimum head and maximum operating sump water elevations should be at least equal to the capacity of the largest incremental change in discharge capacity. When a bypass is located on a pump discharge line, its capacity under the same conditions of head should be sufficient to provide the desired operating cycle, usually one-half the capacity of the largest pump. In both cases, the increased capacity of pumps at lower than design heads should be recognized. Butterfly valves are normally used to control the bypass flow. These valves are provided with power operators when manual operation requires more then a 110-N (25-lb) pull on the valve operator.

(5) The determination of sump capacity requires close coordination with the entire design of the pumping station. Basic factors such as type of prime mover, number and size of pumps, and size and arrangement of station are affected by, or have an effect on, sump capacity. Selection of design to provide adequate sump capacity should be based on a comparison of overall cost for each installation. Factors to be considered include cost of sump structure and superstructure, higher price of equipment accompanying any increase in pumping requirements, increased cost of variable-capacity in lieu of fixed-capacity pumps, and cost of operation.

6-3. Surges in Sump

a. General. Surges may occur in pipelines which flow full and are subject to sudden changes in rate of discharge. This is possible where the sump area and adjacent areas have too small a water volume. Serious damage could occur if proper consideration is not given to the effects of surges in designing the pump station. Surges and resulting rapid fluctuations of the water surface elevations in the sump could also affect the proper operation of the automatic stop controls of the pump. The condition of a surcharged pipeline discharging to a pump station sump may be considered somewhat analogous to the penstock and surge tank of a hydroelectric powerplant. HDC should be consulted under these conditions.

b. Amount of surge. The height to which the water will surge in the pump sump is a function of the length of a pipeline flowing full, the cross-sectional area of the pipeline, the volume of the sump, the change in pump discharge, and the friction losses. An exact mathematical solution of the problem is often practically impossible because of the many changes in pipe size and the numerous inlet points on a sewer system. However, approximate methods, developed by HDC, permit mathematical treatment of the problem and give results sufficiently accurate for design purposes.

c. Provisions for protection against surge. Certain features inherent in the design of pumping stations and sewer systems automatically supply a dampening effect on surges. Various laterals and manholes of the sewer system, the operating sump, and intake and trash rack wells act as surge tanks. Use of adjustable-blade pumps or variable-speed motors will allow gradual reduction of pump discharge upon shutdown and would reduce operational difficulties arising from surges. In cases where the surge will be great, consideration of one of the following methods will aid in solving the problem.

(1) Raise the operating floor of the pumping station above ground level and provide overflow openings below the station floor. In order to confine the effluent and facilitate its removal, a catch basin would have to be constructed adjacent to the forebay, with a gravity drain to return the overflow to the station. This method would protect the station from damage due to extremely large surges that might be caused by total station shutdown, but ordinarily would not alleviate the smaller surges due to shutdown of single pumps, which may cause operational difficulties.

(2) Stations having the operating floor above the high-water elevation or located outside the line of protection may have flap-gated bypasses from the station sump pump intake to a pressure discharge chamber or directly into the stream. This arrangement might require changes in the station design, particularly in the design of the operating floor which may be subject to upward pressures. This method can be used to protect the station from extremely large surges. The effectiveness of the method in reducing smaller surges would be dependent upon the elevation of the water surface in the discharge chamber or in the stream at the start of the surge and upon the elevation at which the bypasses are placed.

(3) The horizontal cross-sectional area of the inflow sump could be increased to act as a surge tank. The sump dimensions should not be increased above that area required for proper sump flow.

(4) A special surge tank or a surge basin could be used at some point on the pipeline near the pumping station. The effectiveness of this method is dependent upon the horizonal cross-sectional area provided by the elevation at which the surge tank becomes effective. This method is effective in reducing all surges, both in the sump and in the connecting sewer. However, for greatest effect at the pumping station, the surge tank or surge basin should be placed as close to the station as practicable.

(5) For a large pipeline, an initial intake sump could be provided with a regulating weir into a second sump at one side in order to maintain a constant hydraulic gradient in the sewer. This method would prevent surges from moderate changes in pump discharge but may not greatly affect large surges resulting from total station shutdown and may not afford sufficient protection for the pumping station.

6-4. Trash Racks

a. Racks. Except for stations of minor importance and sewage-type pumping stations, all flows into flood protection pumping stations should be screened before reaching the pumps. Conventional bar screens (trash racks) are the preferred method of screening. Suction strainers should be avoided as they clog readily and are difficult to clean. Trash racks must be located to allow incoming flows to pass through the rack before reaching any pump intake, flow to be evenly distributed over the submerged rack surface, and raking to be accomplished coincident with pump operation. Trash racks located in the sewer which flows by the pumping station should be readily removable, and minimal means should be provided to allow the racks to be raised above the maximum sump level and secured when the station is not in use. Trash racks should always be located outside the station superstructure in order that operating areas are not exposed to the moisture and fumes usually present during raking operations, and to facilitate disposal of trash accumulations. Where flows are adequately screened prior to entry into the collecting system by grated catch basins or other methods, trash racks need not always be provided. However, omission of trash racks must be based upon sound engineering judgment and economic considerations and must be justified and explained in the design analysis.

*b. Effective areas and bar spacing***.** Trash racks should have ample net area so that the velocity of the flow through the gross rack area does not exceed 0.76 m/sec (2.5 fps). The clear opening between bars should be approximately 45 mm (1-3/4 in.), but may be greater if justified by the size and type of pumps to be protected, but should not exceed 75 mm (3 in.) in any case. Bar spacing should be coordinated with the pump manufacturer.

Chapter 7
Discharge Arrangement

7-1. General

The method and structures required to transport pumping station discharge are determined largely by the type of protection works adjacent to the pumping station, the location of the station with relation to existing sewers, and the desirability of avoiding layouts involving pressure conduits, especially under levees on yielding foundations. Pressure conduits can be avoided by carrying the discharge over the levees by individual pipes. If the protection works consist of a floodwall, pressure conduits should be avoided by locating the pumping station on the protection line and making the discharge through the riverside wall of the pumping station into a gravity conduit or open discharge chamber. If the pumping station is offset from the floodwall, special arrangement of the discharge pipes may be required. The designer should review EM 1110-2-3104 and EM 1110-2-1913, Chapter 8, and coordinate the discharge arrangement with the structural and geotechnical engineers.

a. Pipe connected to pumps. In general, a single pipeline should be installed and direct-connected to each pump. In the case of pumping stations of small capacity (315 ℓ/sec (5,000 gpm) or less), two pumps may be connected to the same line. The connection should be made inside the pumping station or a valve vault outside of the pumping station by a fitting. Check valves and gate valves should be inserted in the connecting line between the fitting and the pump to prevent reverse flow through an idle pump when the other pump(s) are operating.

b. Number and location of flexible couplings. Flexible couplings should be used wherever the pipe runs into or out of concrete structures, at bends or miters, and at other points where differential settlement or normal expansion and contraction of the pipe are anticipated. Where the pipe leaves the station wall, the first flexible coupling shall be located not more than 1 m (3 ft) from the wall. A second flexible coupling should be located no further than 2 m (7 ft) from the first.

7-2. Discharge Over the Levee

Due to the large settlement which may occur, discharge over levees should be limited to metal pipes, preferably ductile iron or coated steel, suitable for use with flexible couplings. Concrete conduits and precast reinforced concrete or reinforced sewer pipe are not satisfactory. The invert of the highest point of the discharge line should be the same as the top of the protective works at the pump station site.

a. Siphonic discharge lines. Over-the-levee discharge lines should be studied to determine if their use as a siphon is economical. Usually a siphon can be justified on power saved due to the lower head when primed. Pumps should be selected to operate over the entire range of heads provided by siphon usage. The pumping unit shall be capable of self priming the discharge pipe. Two types of discharge pipe terminations are used for siphon systems: concrete structures with a weir to submerge the pipe end or a turned up end (saxophone) discharge pipe (Plates 10 and 11). Both types are acceptable, and selections can be based on costs of construction and operation. Valves on the end of the discharge pipe should not be used to hold a siphon in the pipe. Plates 4 and 5 show a plant built within a levee with a siphon discharge.

b. Air vents. All over-the-levee discharge lines should be provided with an unobstructed (free) air vent at the highest point. Suitable protection should be provided to prevent the vent being rendered inoperative by vandalism.

c. Pipe supports. Pipe may be supported on the surface of the levee and should be completely covered by mounding, except on the riverside of the levee where the pipe should be placed in a trench to avoid concentration of levee erosion by flood flows. Covering the pipe in this manner affords protection against displacement, facilitates maintenance of levee surfaces, and provides access over the pipe for pedestrian or vehicular traffic.

7-3. Pressure Discharge Lines

Installing pumping station discharge lines under or through levees or floodwalls and subjecting these lines to flow under pressure should be avoided whenever possible. It is realized, however, that conditions may exist which require or dictate their use. As an example, a large discharge line may be carried under a floodwall when right-of-way for a pumping station would necessitate several bends. When it is not practicable to avoid a pressure line under the levee or wall, the pipe will have ample strength and be provided with joints that will provide flexibility with restraint to limit axial movement. Whenever it is necessary to install discharge lines under or through levees or floodwalls, seepage protection should be provided as required in EM 1110-2-1913.

7-4. Backflow Prevention

The type of pumps usually used for flood control pumping stations provide practically no restrictions to backflow. A suitable means must be provided to prevent backflow in the pump discharge lines. In planning pumping installations, the practices outlined below should be followed.

a. General. The basic requirement for pump discharge lines, in which backflow can occur without siphon action, is to provide two means of preventing backflow--one means for normal use and the other for emergency use in the event of failure of the normal method. The emergency method may consist of either a means of bulkheading the end of the pipe, or, in special cases, a separate shutoff valve on the discharge line.

b. Discharge chamber. For discharge lines terminating in the discharge chamber adjacent to the station, flap valves alone may be considered adequate protection against backflow for normal operation. The design of the structure should afford access to the valves at all flood stages. The discharge chamber should have slots for bulkheads at the exit of the chamber and at each flap gate location. The walls of the discharge chamber should be constructed to at least the protection elevation. This will allow, in the event of the failure of a flap gate, bulkheads to be placed at the exit of the chamber and dry access to repair the disabled flap gate.

c. Over levee or floodwall. Discharge lines over the levee or floodwall should have the invert of the high point of such discharge lines at or above the design protection elevation, except where unusual conditions exist that would justify deviation. All such deviations must be approved by higher authority. All discharge lines of this type should be provided with an emergency means of stopping backflow if the river stage should exceed the invert elevation of the highest part of the discharge line. A means to allow application of compressed air, from an emergency source, to the high point of the discharge line would be an acceptable method. Discharge lines having the invert at a lower elevation than the design protection elevation must be provided with a valve located at the high point of the discharge lines. The valve should be accessible at all flood levels and may require motor operation if the discharge pipe size is greater than 450 mm (18 in.) in diameter. In addition to the motor-operated valve, a manual-operated valve of the same size is required.

d. Under protective works. When discharge lines running under protective works cannot be avoided and the pipes are terminated in a headwall, flap valves alone are considered inadequate. If flap gates are used, a separate well should be constructed to the protection elevation from which access to the flap valve, comparable to that described above for a discharge chamber, is possible. This structure should be located and designed such that during periods of idleness of the pump station the tendency for silt, loose rock, debris, and floatable material to collect in sufficient amount to interfere with gate operation is minimized. An alternate procedure would be to provide a shutoff valve in each discharge pipe in addition to the flap gate.

e. Underground discharge lines. Underground discharge lines in small pumping stations should have a check valve on each pump discharge line to prevent backflow. Gate valves should always be provided on the discharge side of such check valves to permit maintenance of the check valves. Where butterfly valves are installed in bypasses between river and sump, a slide gate or emergency bulkhead over the riverside orifice of the bypass, or a gate valve on the riverside of the butterfly valve, should be provided for emergency closure of the bypass.

f. Emergency closures. Emergency closures may require a removable bulkhead or stoplogs. These should be furnished where openings need to be closed in a short time period. In such cases, slots should be provided in the walls of the passage to be closed, with provisions made for placing and removing the closure parts. Stoplogs and bulkheads should be made of noncorrosive material of ample strength to sustain the imposed loads. They should be provided with hooks to permit handling by means of a lifting device. Bulkheads should be designed for placement under all operating conditions using a mobile crane if required by the weight of the bulkheads.

7-5. Outlet Structure

An outlet structure should be constructed at the end of the pipes in order to protect the levee from erosion due to the pump discharge and the river current. Typical outlet structure designs are contained in EM 1110-2-3104. Since in most instances the pump will be in operation only at times when the streamflow is above the discharge outlet, the effect of erosion from the discharge is minimized. In most instances a concrete structure consisting of headwall, wing walls, apron, and cutoff wall will suffice. Rip-rap protection of the bottom and side of the discharge channel should be provided to protect the levee against erosion. The pump discharge channel should be sloped to drain away from the discharge structure. A combination discharge and reverse flow shut off gatewell

located on the riverside of the levee may be an economical arrangement, and is desirable in view of the protection afforded the shutoff gates. Where structures are accessible to children or the general public, wall heights should be minimized or pipe railing or other barriers should be installed.

Chapter 8
Station Auxiliaries

8-1. General

For the majority of pumping stations, auxiliary equipment will be defined as station cranes and hoists required for placement and removal of equipment, trash raking and conveying equipment, fire protection, heating and ventilating, office facilities, and emergency power backup system.

8-2. Station Cranes

a. General. An overhead traveling crane should be installed in all stations except those of small size where such equipment would not be practicable or economical. In small pumping stations removable roof hatches located over the equipment should be considered. Stations using an all metal building can also be constructed to have roof hatches over the equipment. The metal building should be designed to allow removing the roof hatches without reducing the building's stability. A mobile crane necessary to remove the equipment will not be furnished by the Government. Load and reach requirements of a mobile crane, for removal of the pumping units, should be furnished with the design of the building. A concrete slab outside of the equipment door should be provided and sized to hold the larger pieces of the disassembled pumping unit and driver.

b. Overhead. Overhead cranes with a capacity over 3 metric tons (3.3 tons) should be provided with an electric-motor-driven equipment hoist, trolley, and bridge. Monorail cranes with the travel rail located over the equipment should also be considered. When providing a monorail-type crane, there should be sufficient space in the station to place equipment. An alternate would be to continue the rail outside of the station where room would be provided to place equipment. The crane should be sized to lift the heaviest, fully assembled, single piece of equipment.

c. Mobile. The mobile crane should be located within 8 hr travel time to the pumping station. Roads to the station and clearance of utility lines should be confirmed after the mobile crane is sized. If available cranes cannot meet these conditions, then an inside overhead crane must be provided.

8-3. Trash Rakes

a. Rakes. EM 1110-2-3105 provides detailed information about the selection of raking equipment. The two basic types are hand and mechanical raking. The decision to use either hand or mechanical raking should be based on the amount and characteristics of the debris, station configuration, safety, and engineering judgment. Operating personnel should never have to hand rake and handle debris coming from a sanitary or combined sewer. Also, mechanical raking should be used if the station configuration presents a danger for personnel; for example, a very deep sump, significant amount of debris, or the weight of debris will require mechanical lifting capability.

*b. Trash disposal***.** Suitable provision must be made in design of the trash rack chambers to permit storage and removal of accumulated trash with reasonable ease. Truck access to locations where trash is deposited upon removal from the trash rack chamber should be provided in order to avoid laborious transfer procedures in final trash removal.

8-4. Fire Protection

Pumping stations are considered Special Purpose Industrial Occupancy as defined in National Fire Protection Association (NFPA) 101, Chapter 28. Fire protection should be provided by portable fire extinguishers. Fire protection requirements for diesel driven stations are provided in NFPA 37. The number, size, and type of portable fire extinguisher shall be provided as specified in NFPA 10.

8-5. Heating and Ventilation

a. Heating. In general, space heating of the superstructure should be provided in flood control pumping stations located in colder climates. The space heater should be sized to maintain a minimum temperature of 12.8 °C (55 °F).

b. Ventilation.

(1) Proper ventilation of pumping stations is an important design consideration. A means should be provided for gravity ventilation of the sump at all times to prevent concentrations of vapors or gases which may result in damage to the structure or injury to personnel. Forced ventilation should be used when pumping water may contain sewage. The superstructure should have

ventilation to remove heat produced by the equipment. Power-driven roof or wall fans can be used to ventilate the superstructure.

(2) All power ventilation equipment controls should be located adjacent to the entrance door. All ventilation should be rated for operating in an explosive atmosphere.

8-6. Office Facilities

a. Office space. An enclosed office should be provided for all stations over 3 cu m/sec (100 cfs) total capacity. A desk, chair, and filing cabinet to store as-builts and operation and maintenance manuals should be provided. Sound proofing should be provided for stations with diesel prime movers. Heating and cooling should be provided as necessary.

b. Sanitary facilities. Sanitary facilities should be provided for all pumping stations. These facilities will range from portable units for small stations with little operating time to more conventional facilities with showers for the larger stations and shall meet the requirements of EM 385-1-1. For example, a larger station may have a total capacity over 90 cu m/sec (3,000 cfs) with a workforce of over 12 people.

c. Drinking water. An adequate supply of drinking water shall be provided in accordance with EM 385-1-1.

Appendix A
Plates

Plate 1. Section views of the gatewell type pumping station illustrating the different type discharge systems.

Plate 2. A pumping station with the pump(s) located in a gatewell. The pumps used at this station were submersible propeller type supported in a discharge tube fitted with flap gates. This type station is economical to construct. This station is the Pelucia Creek Pumping Station located in Greenwood, Mississippi. It was designed by the St. Louis District and constructed by the Vicksburg District and is part of the Yazoo River Basin, Greenwood Protection Works Project.

Plate 3. Plan views of the gatewell type station shown in Plate 2. The pump discharge tube location was determined by model tests at WES. The discharge tube is placed out of the flow area of the gravity drain. Two different discharge methods are shown to illustrate types of discharge when using a submersible pump.

Plate 4. Section view of a 7-cu-m/sec (250-cfs) pump at Lake Chicot Pumping Plant. This view shows the vertical pump, siphon discharge, and electric motor drive. This station is located in the Mississippi levee system. It is a project of the Vicksburg District.

Plate 5. Site plan for the Lake Chicot Pumping Plant shown in Plate 4.

Plate 6. This pumping station contains five submersible pumps each discharging into a discharge chamber. Flow is taken from a stormwater sewer. An intake is used to provide correct flow to the pumps. This intake diffuser was model tested by the pump manufacturer. This pumping station, the Northside Pumping Station located in Richmond, Virginia, was designed by the St. Louis District and constructed by the Norfolk District as part of the James River Basin, Richmond Local Flood Protection Project.

Plate 7. A section through the sump and forebay of the pumping station shown in Plate 6. The station is provided with a sump intake gate and mechanical trash raking equipment. A full operating room with an overhead crane and roof ventilator was provided. The site for this station required a full building over the sump rather than a partial building housing electrical equipment and office space.

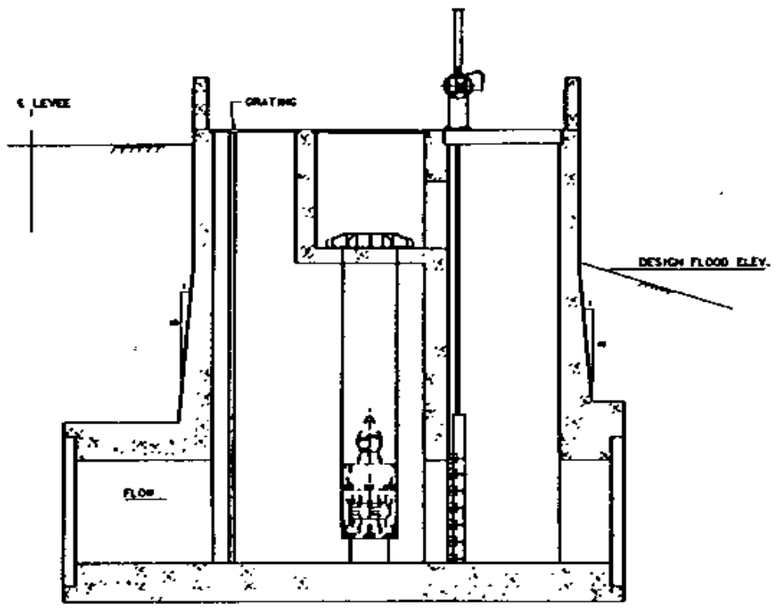
Plate 8. A pumping station equipped with a discharge chamber, formed suction intake (FSI) on the pump, mechanical trash rake, and sump closure gate. The station has an electric-motor-driven overhead hoist and uses station layout including gravity drains under the discharge chambers in the discharge chamber. Bulkhead slots for stopping back flow are not shown. This station is the Alton Pumping Station and is located in Alton, Illinois. It was designed and constructed by the St. Louis District as part of the Melvin Price Locks and Dam Project.

Plate 9. A site plan for the pumping station shown in Plate 8. The station is located landside of the line of protection (levee). Note the emergency closure structure located on the pressure conduits riverside of the line of protection. A structure of this type is required when the discharge chamber of a pumping station is located landside of the line of protection.

Plate 10. A pumping station with an over-the-levee discharge system. The station is also equipped with a siphon assist discharge. The discharge pipe terminates with a saxophone discharge. This station is the Chauvin Bayou Pump Station and is located in Monroe, Louisiana. It was designed by the St. Louis District and constructed by the Vicksburg District as part of the Ouachita River Basin, Monroe, Louisiana, Flood Protection Project.

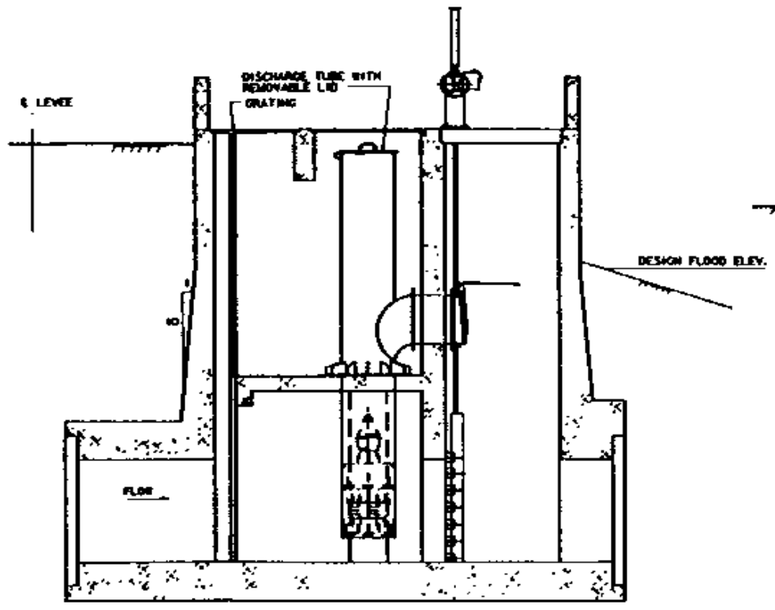
Plate 11. A site plan for the pumping station shown in Plate 10. The station is located adjacent to the gravity flow structures. A separate inlet structure had to be provided to the pumping station.

Plate 12. This pumping station design is used when required pumping capacity is less than 566 ℓ/sec (20 cfs). The pumps are submersible type and are removed by the use of guide rails and a discharge connection fastened to the floor. The size of the inlet lines to the station are usually small and limit the trash size that reaches the pump. A removable trash basket can be used to catch large objects. This type station may be located where occasional flooding is possible without any damage to the equipment.



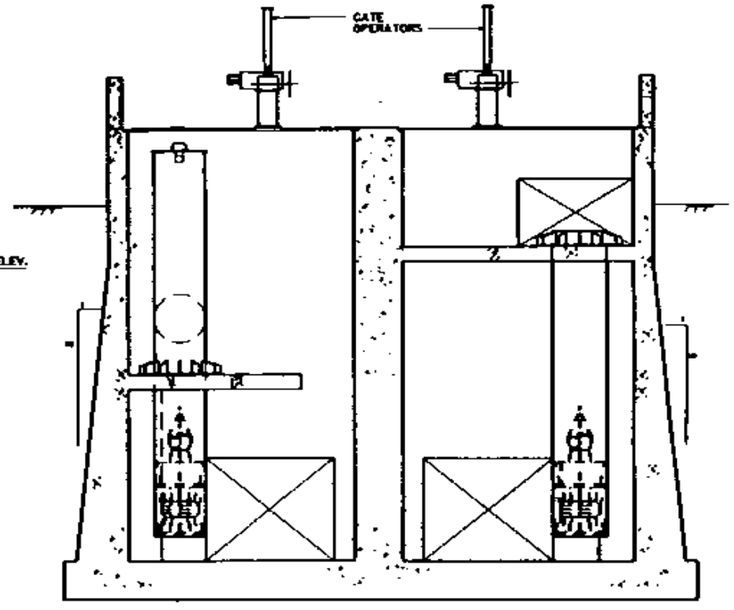
"FREE-FALL" DISCHARGE

SECTION C-C FROM PLATE 3



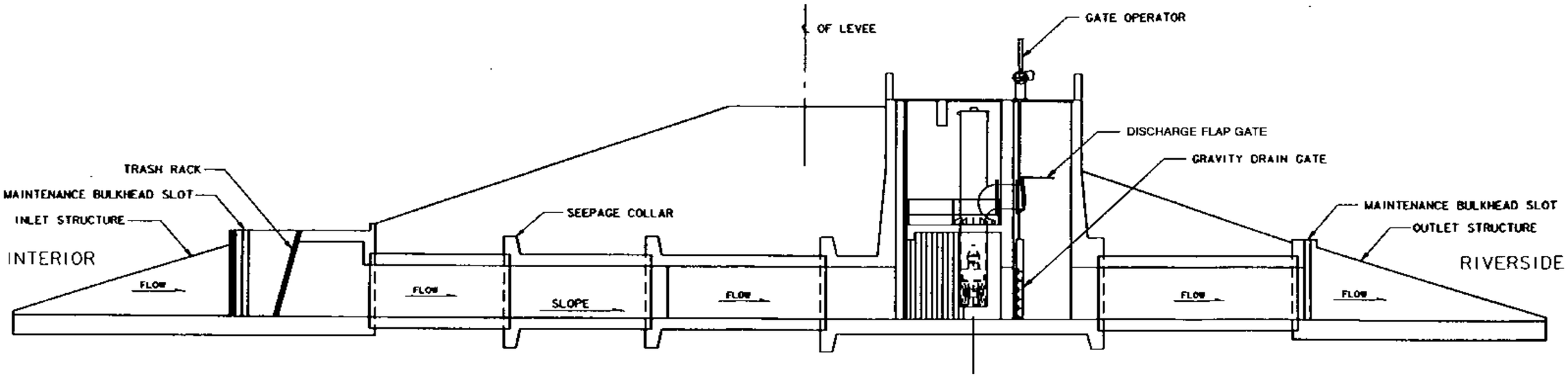
"FLAP GATE" DISCHARGE

SECTION A-A FROM PLATE 3

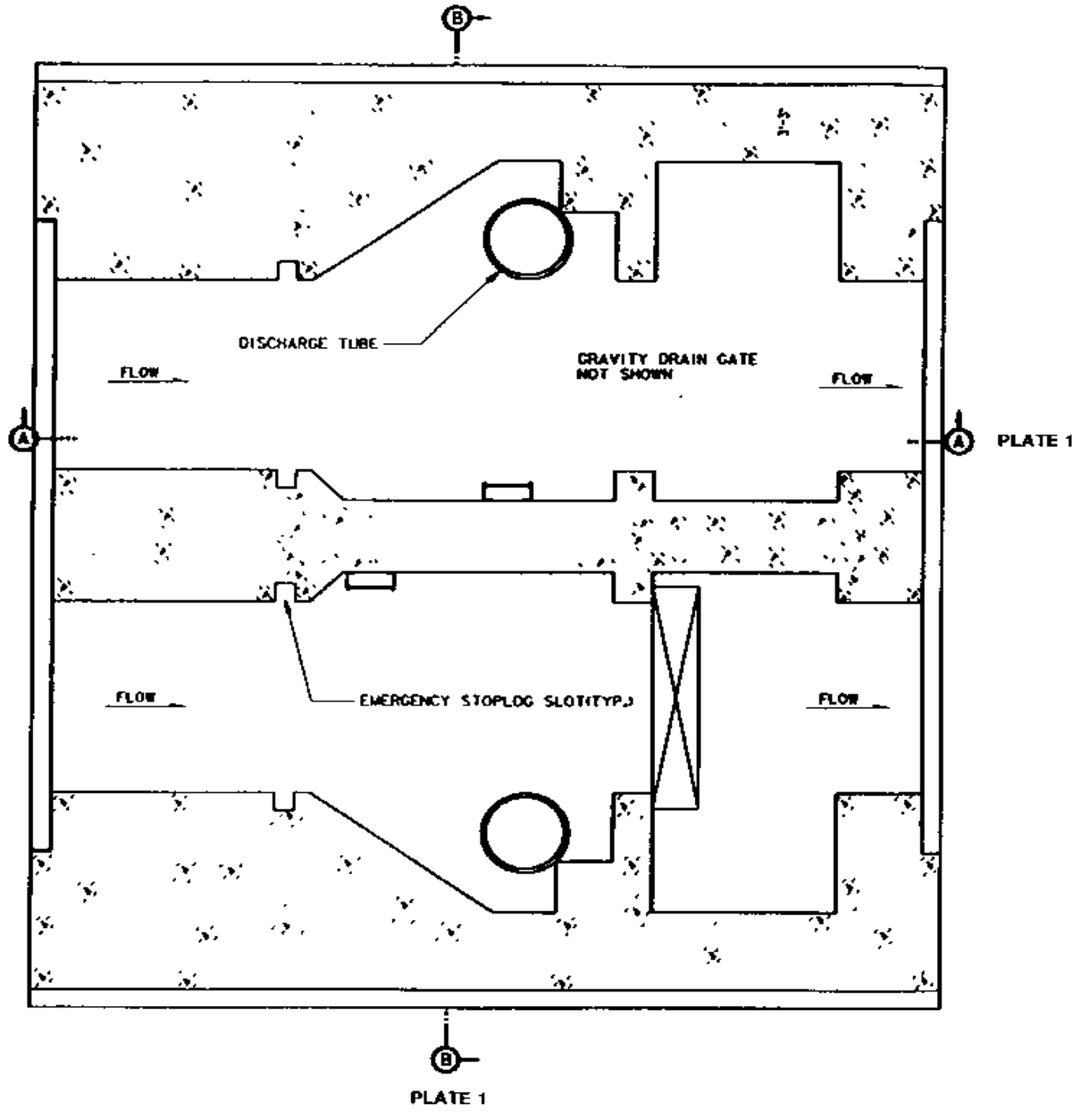


DISCHARGE ARRANGEMENTS

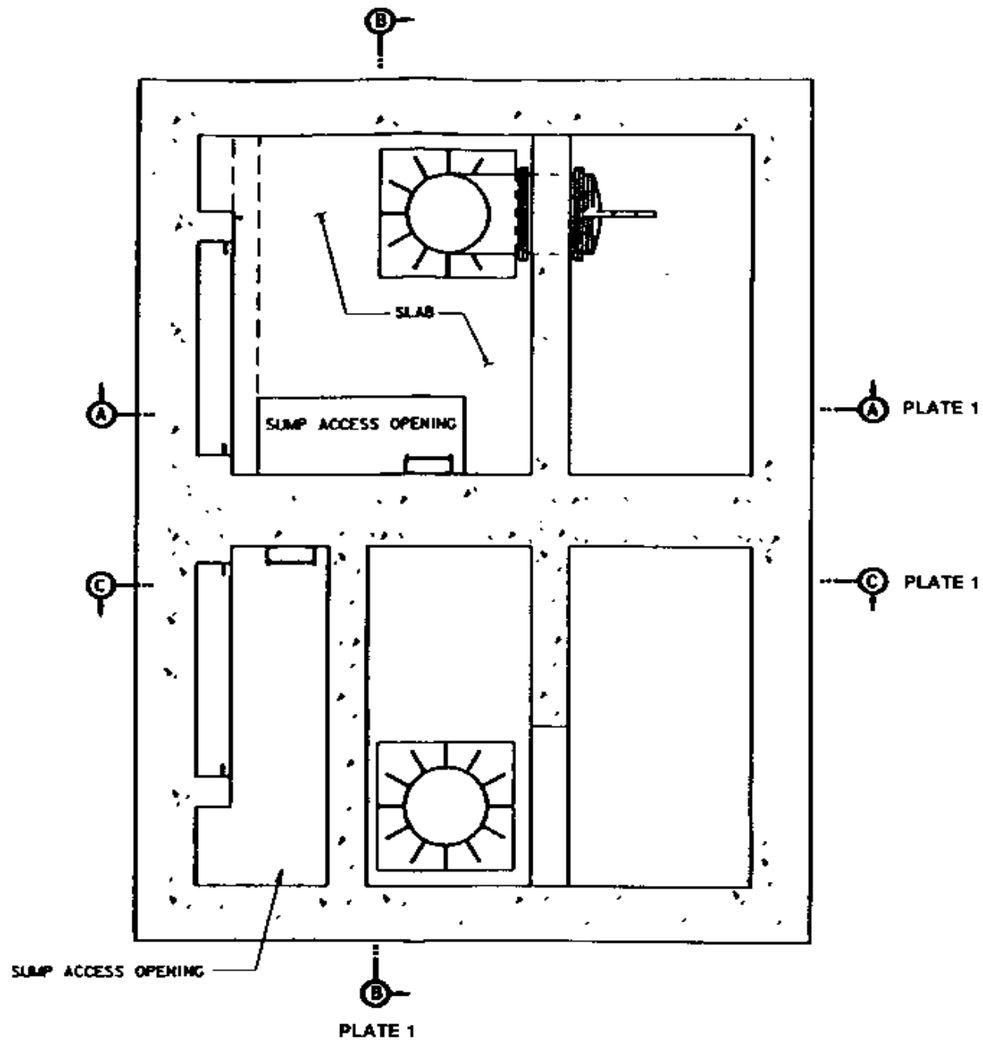
SECTION B-B FROM PLATE 3


℄ OF LEVEE
GATE OPERATOR
DISCHARGE FLAP GATE
GRAVITY DRAIN GATE
TRASH RACK
MAINTENANCE BULKHEAD SLOT
INLET STRUCTURE
SEEPAGE COLLAR
MAINTENANCE BULKHEAD SLOT
OUTLET STRUCTURE
INTERIOR
RIVERSIDE
FLOW
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SLOPE
FLOW
FLOW
FLOW

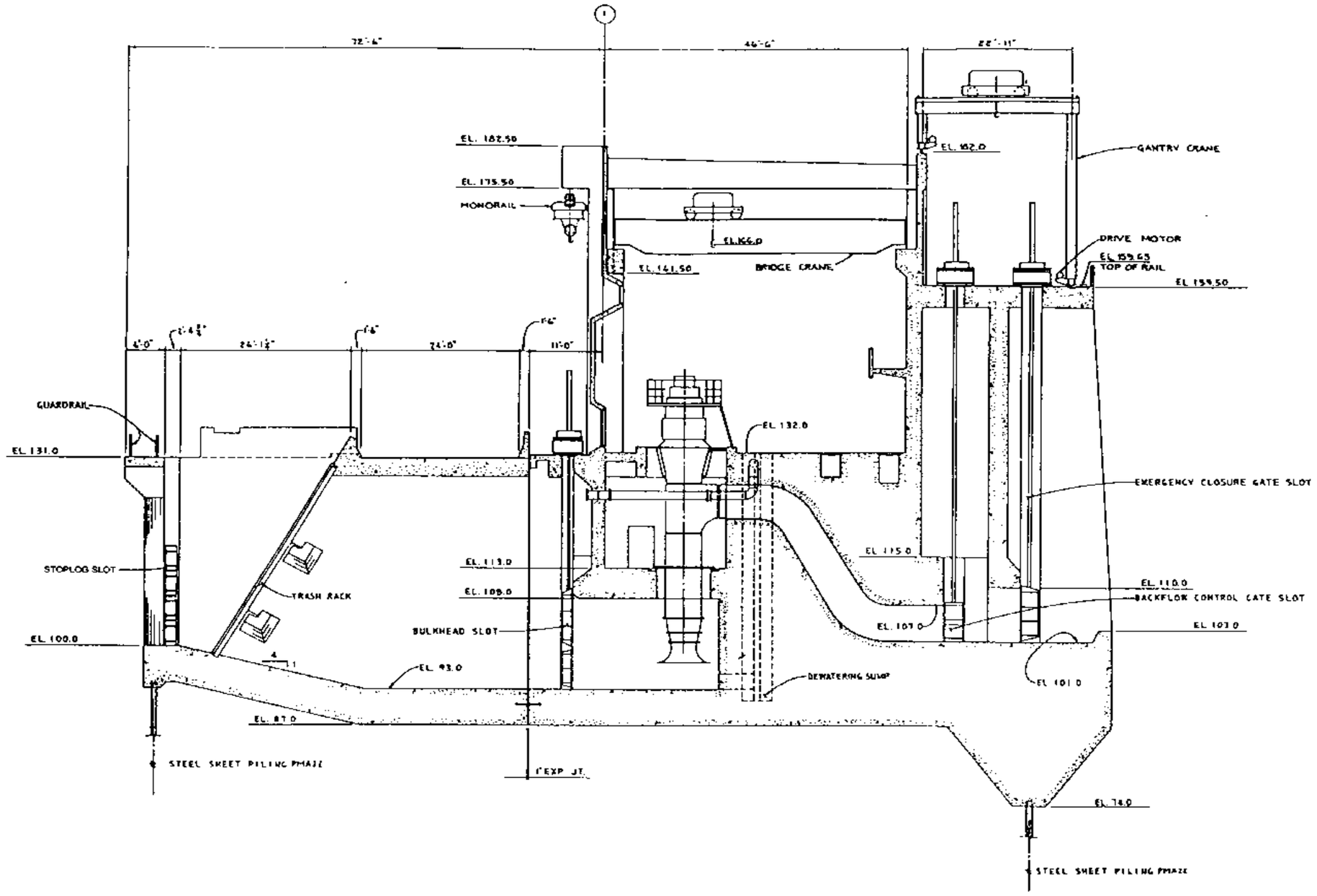
ELEVATION

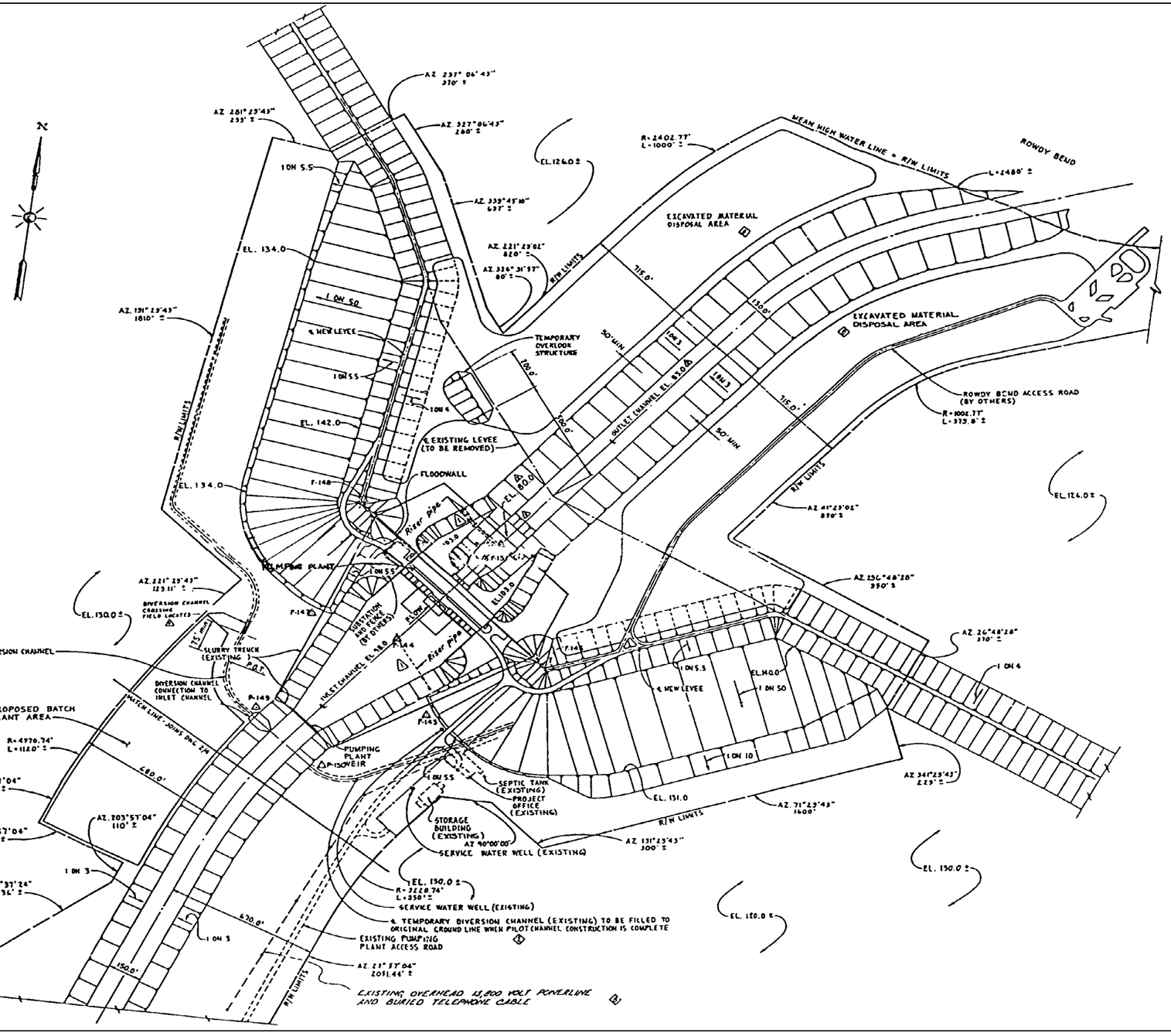


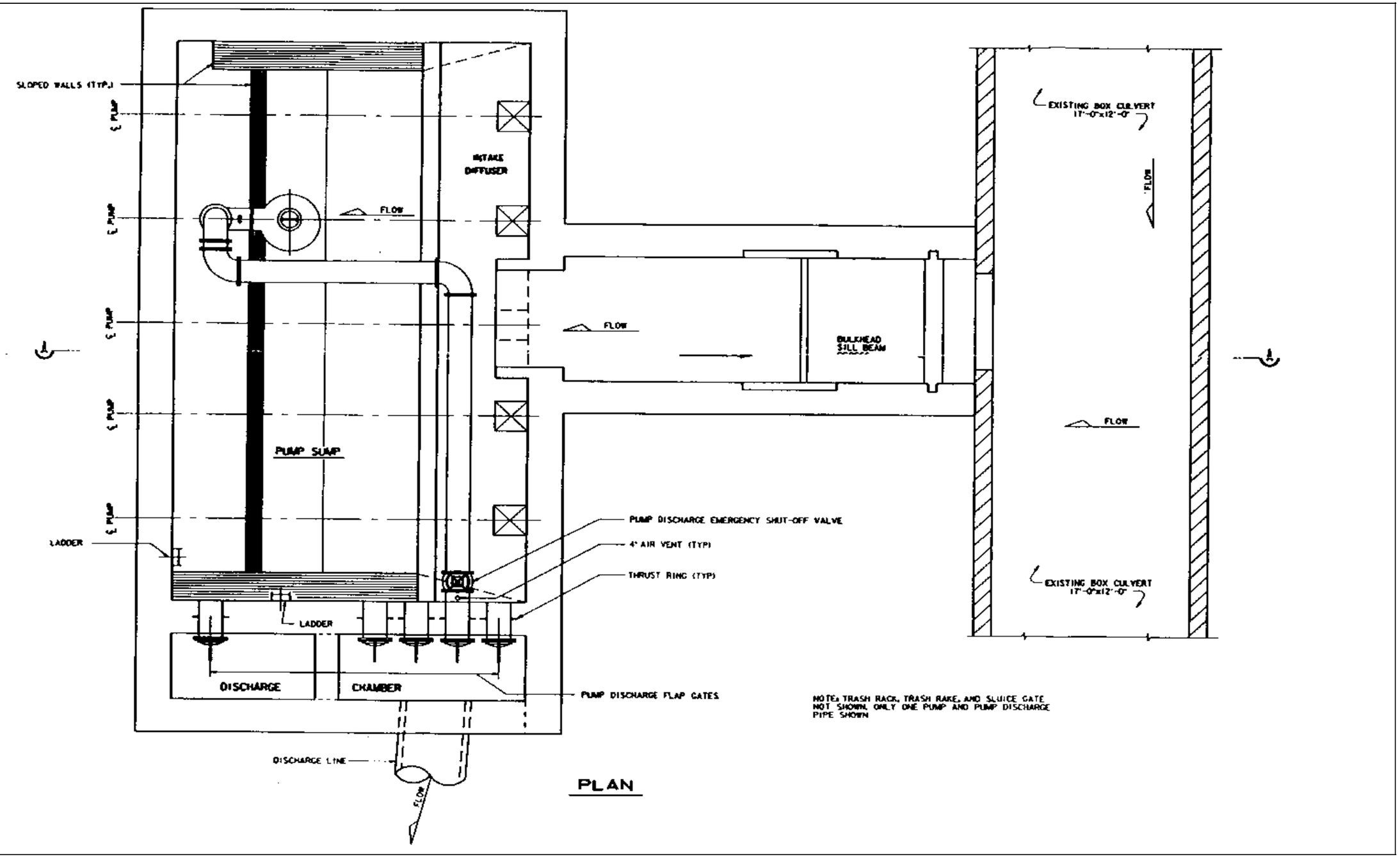
SUMP LEVEL



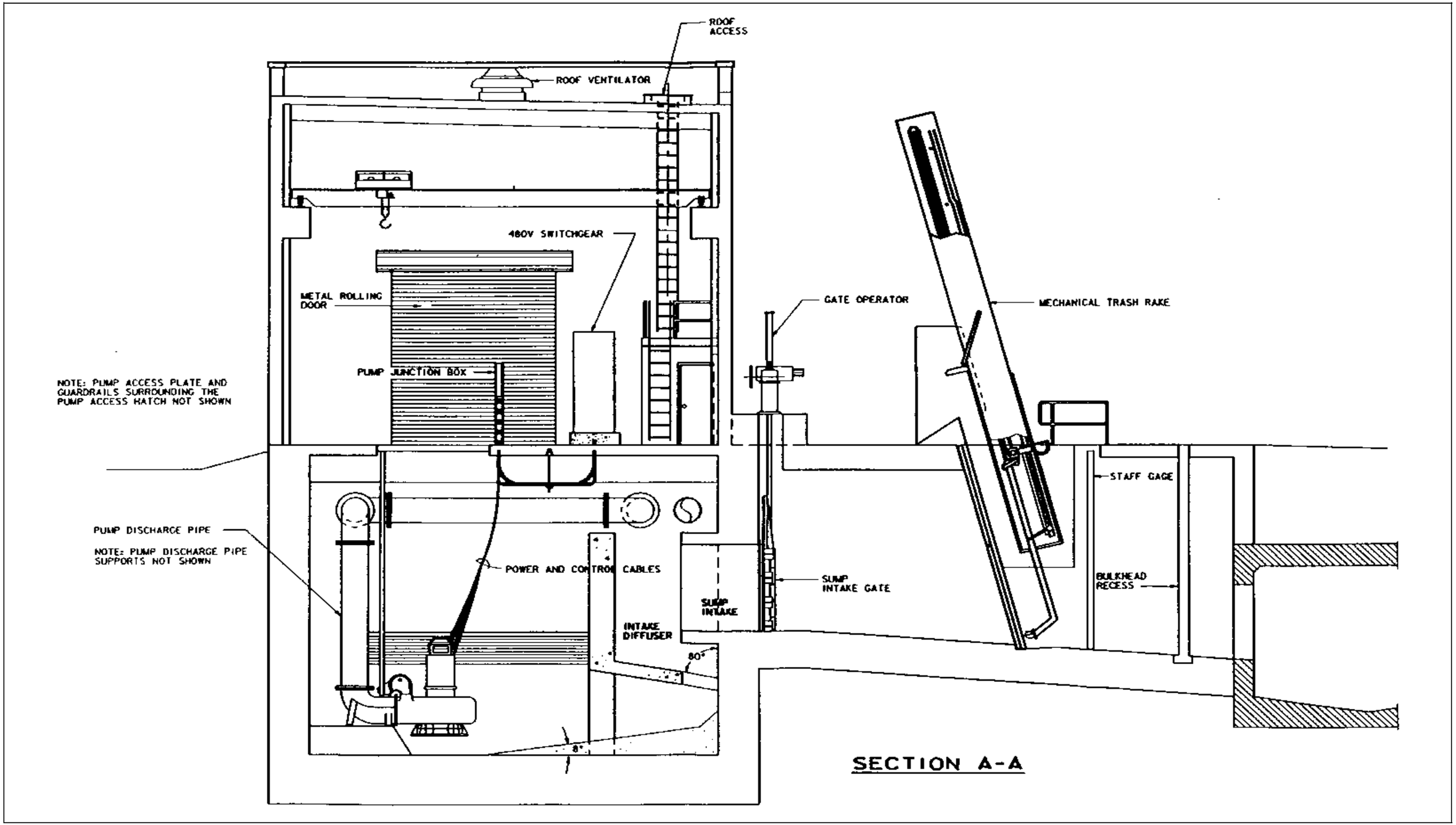
OPERATING FLOOR LEVEL


72'-6"
46'-6"
22'-11"
EL. 182.50
EL. 175.50
MONORAIL
EL. 152.0
GANTRY CRANE
EL. 166.0
BRIDGE CRANE
EL. 141.50
DRIVE MOTOR
EL. 159.63
TOP OF RAIL
EL. 159.50
4'-0"
2'-4½"
24'-11½"
1'-6"
24'-0"
11'-0"
GUARDRAIL
EL. 131.0
EL. 132.0
EMERGENCY CLOSURE GATE SLOT
STOPLOG SLOT
TRASH RACK
EL. 113.0
EL. 109.0
EL. 115.0
EL. 110.0
BACKFLOW CONTROL GATE SLOT
EL. 107.0
EL. 103.0
BULKHEAD SLOT
EL. 100.0
4
1
EL. 93.0
DEWATERING SUMP
EL. 101.0
EL. 87.0
STEEL SHEET PILING PHASE I
I EXP JT
EL. 78.0
STEEL SHEET PILING PHASE II

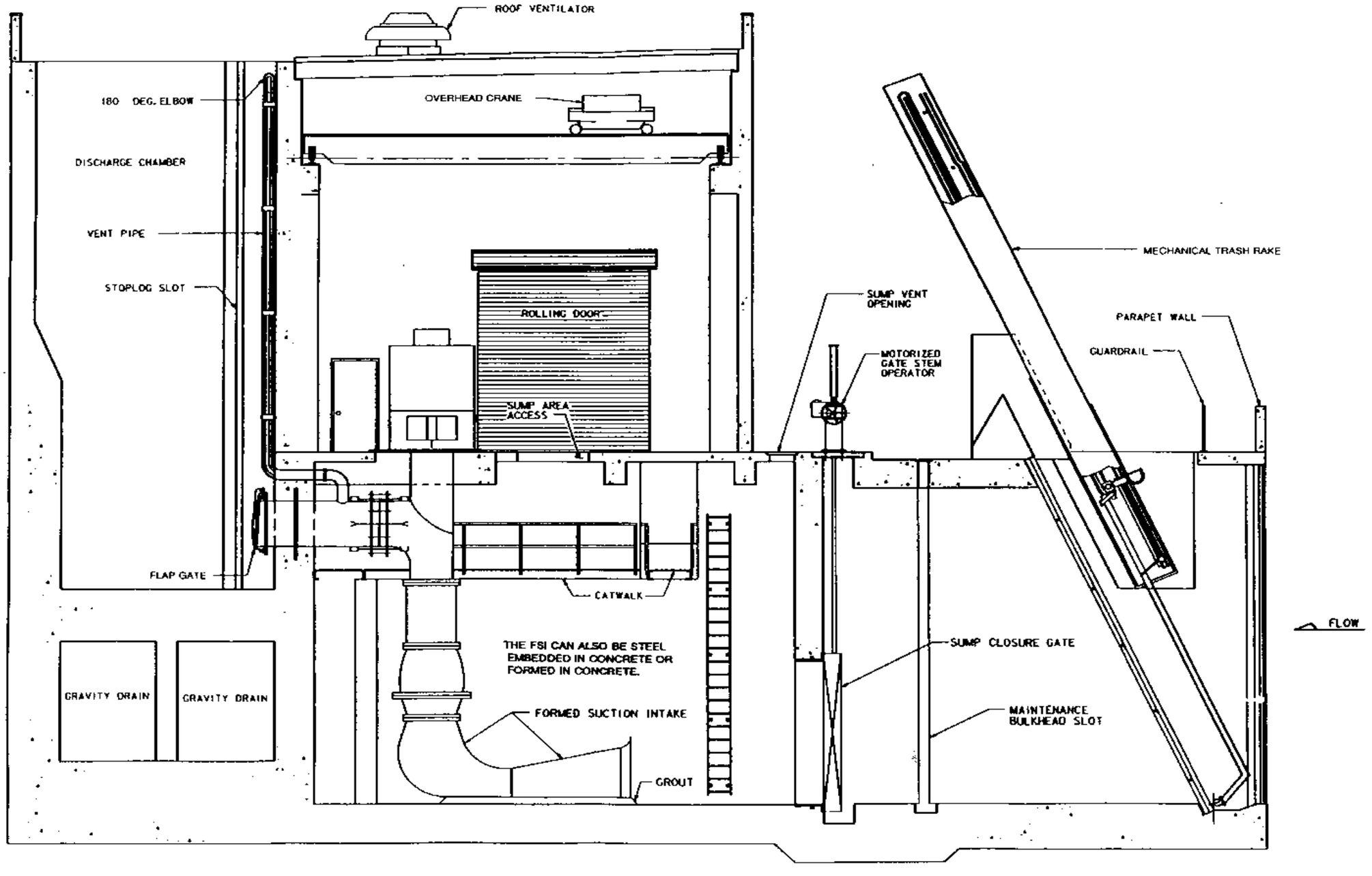

N
AZ 237° 06' 43" 370' ±
AZ 281° 29' 49" 239' ±
AZ 327° 06' 43" 280' ±
EL. 126.0 ±
1 ON 5.5
AZ. 339° 49' 10" 697' ±
EL. 134.0
1 ON 50
AZ. 221° 29' 02" 820' ±
AZ. 336° 31' 57" 80' ±
R/W LIMITS
715.0'
MEAN HIGH WATER LINE = R/W LIMITS
ROWDY BEND
L=2480' ±
EXCAVATED MATERIAL DISPOSAL AREA
(A)
R=2402.77'
L=1000' ±
AZ. 191° 29' 49" 1810' ±
4 NEW LEVEE
1 ON 5.5
TEMPORARY OVERLOOK STRUCTURE
50' MIN
100.0'
1 ON 5
1 ON 4
1350'
EXCAVATED MATERIAL DISPOSAL AREA
(B)
R/W LIMITS
EL. 142.0
& EXISTING LEVEE (TO BE REMOVED)
OUTLET CHANNEL EL. 83.0 ±
715.0'
50' MIN
ROWDY BEND ACCESS ROAD (BY OTHERS)
R=1002.77'
L=373.8' ±
FLOODWALL
F-148
EL. 134.0
EL. 80.0
River pipe
EL. 124.0 ±
AZ 41° 29' 02" 870' ±
PUMPING PLANT
1 ON 5.5
AZ. 236° 48' 28" 390' ±
AZ. 221° 29' 49" 123.11' ±
DIVERSION CHANNEL CROSSING FIELD LOCATED
EL. 130.0 ±
SUBSTATION AND FENCE (BY OTHERS)
EL. 124.0
F-144
River pipe
AZ. 236° 48' 28" 370' ±
& EXISTING DIVERSION CHANNEL
175' min
SLURRY TRENCH (EXISTING)
F-145
1 ON 5.5
EL. 140.0
1 ON 4
DIVERSION CHANNEL CONNECTION TO INLET CHANNEL
INLET CHANNEL EL. 120.0
& NEW LEVEE
1 ON 50
PROPOSED BATCH PLANT AREA
F-149
F-143
PUMPING PLANT
F-150
WEIR
R=4970.74'
L=112.0' ±
1 ON 10
AZ. 341° 29' 49" 229' ±
1 ON 5.5
SEPTIC TANK (EXISTING)
PROJECT OFFICE (EXISTING)
EL. 131.0
AZ. 71° 29' 49" 1600'
AZ. 203° 57' 04" 223.92' ±
AZ. 203° 57' 04" 110' ±
680.0'
R/W LIMITS
STORAGE BUILDING (EXISTING)
AZ 90° 00' 00"
AZ 131° 29' 49" 300' ±
AZ. 293° 57' 04" 420' ±
SERVICE WATER WELL (EXISTING)
EL. 130.0 ±
1 ON 3
AZ. 54° 37' 24" 627.36' ±
R=2228.74'
L=350' ±
SERVICE WATER WELL (EXISTING)
EL. 130.0 ±
670.0'
& TEMPORARY DIVERSION CHANNEL (EXISTING) TO BE FILLED TO ORIGINAL GROUND LINE WHEN PILOT CHANNEL CONSTRUCTION IS COMPLETE
(C)
EXISTING PUMPING PLANT ACCESS ROAD
AZ. 203° 57' 04"
1 ON 3
150.0'
AZ. 23° 57' 04" 2051.44' ±
R/W LIMITS
EXISTING OVERHEAD 13,800 VOLT POWERLINE AND BURIED TELEPHONE CABLE
(D)
EL. 120.0 ±

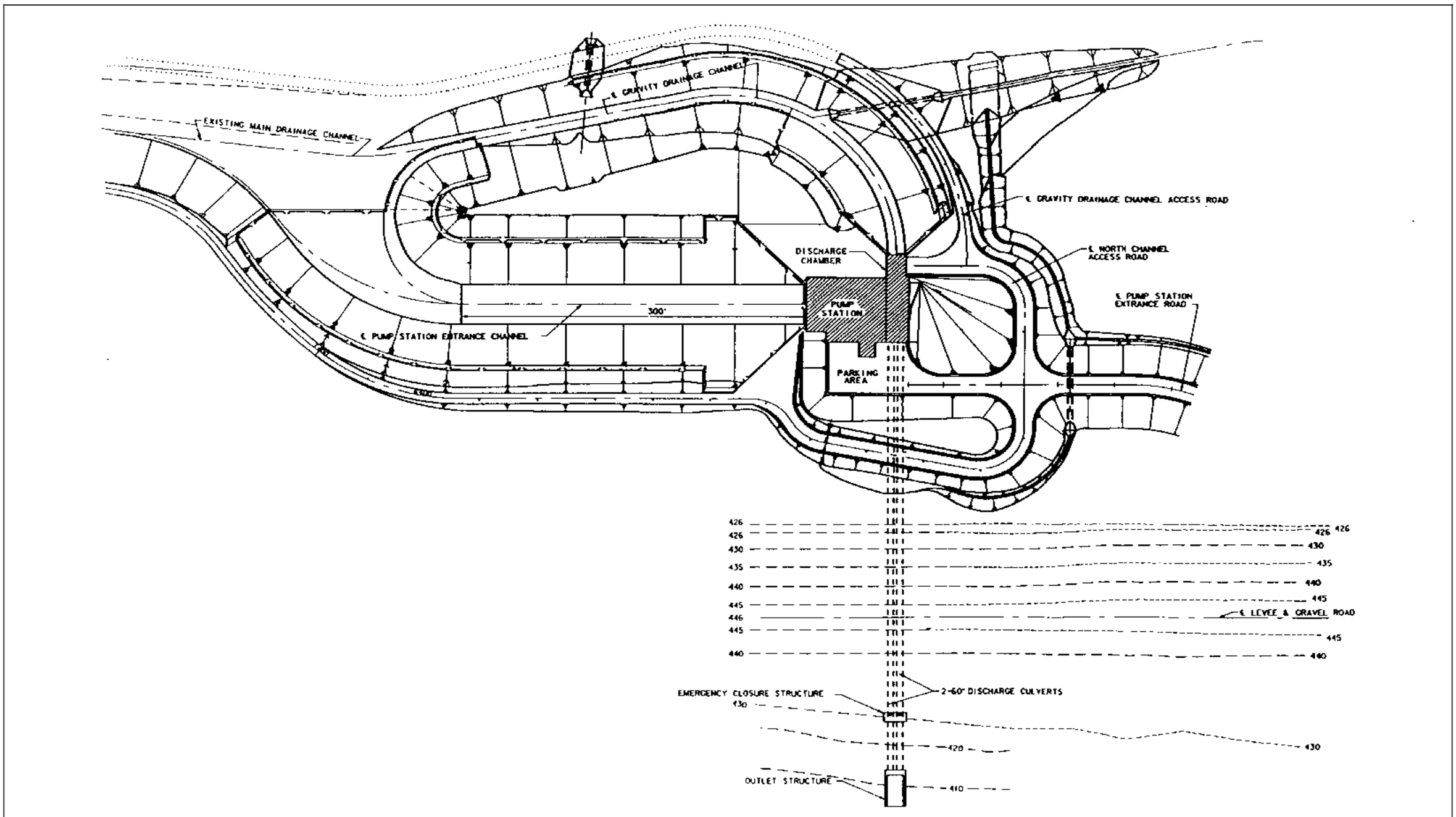

SLOPED WALLS (TYP.)
℄ PUMP
℄ PUMP
℄ PUMP
℄ PUMP
INTAKE DIFFUSER
FLOW
FLOW
BULKHEAD SILL BEAM
PUMP SUMP
℄ PUMP
LADDER
LADDER
PUMP DISCHARGE EMERGENCY SHUT-OFF VALVE
4" AIR VENT (TYP)
THRUST RING (TYP)
DISCHARGE
CHAMBER
PUMP DISCHARGE FLAP GATES
DISCHARGE LINE
FLOW
EXISTING BOX CULVERT 17'-0"x12'-0"
FLOW
FLOW
EXISTING BOX CULVERT 17'-0"x12'-0"
NOTE: TRASH RACK, TRASH RAKE, AND SLUICE GATE NOT SHOWN. ONLY ONE PUMP AND PUMP DISCHARGE PIPE SHOWN

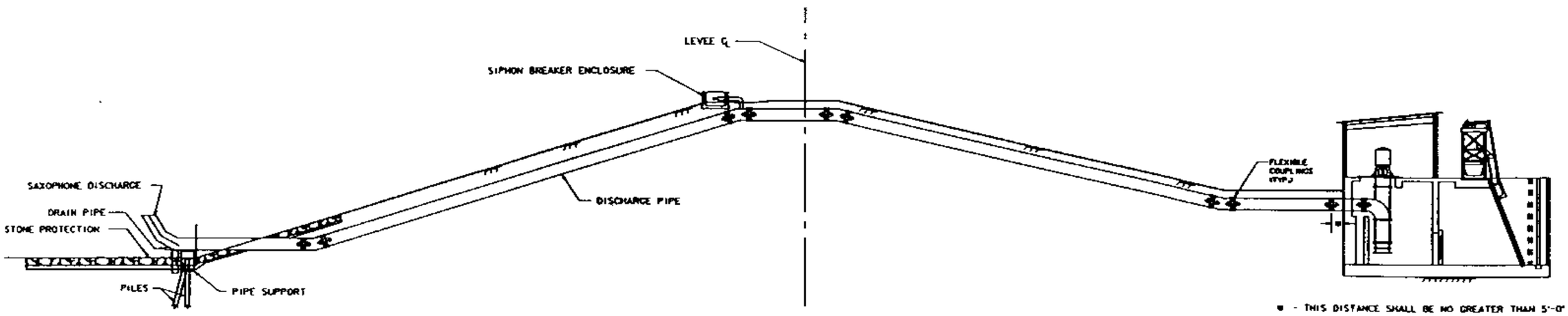
PLAN

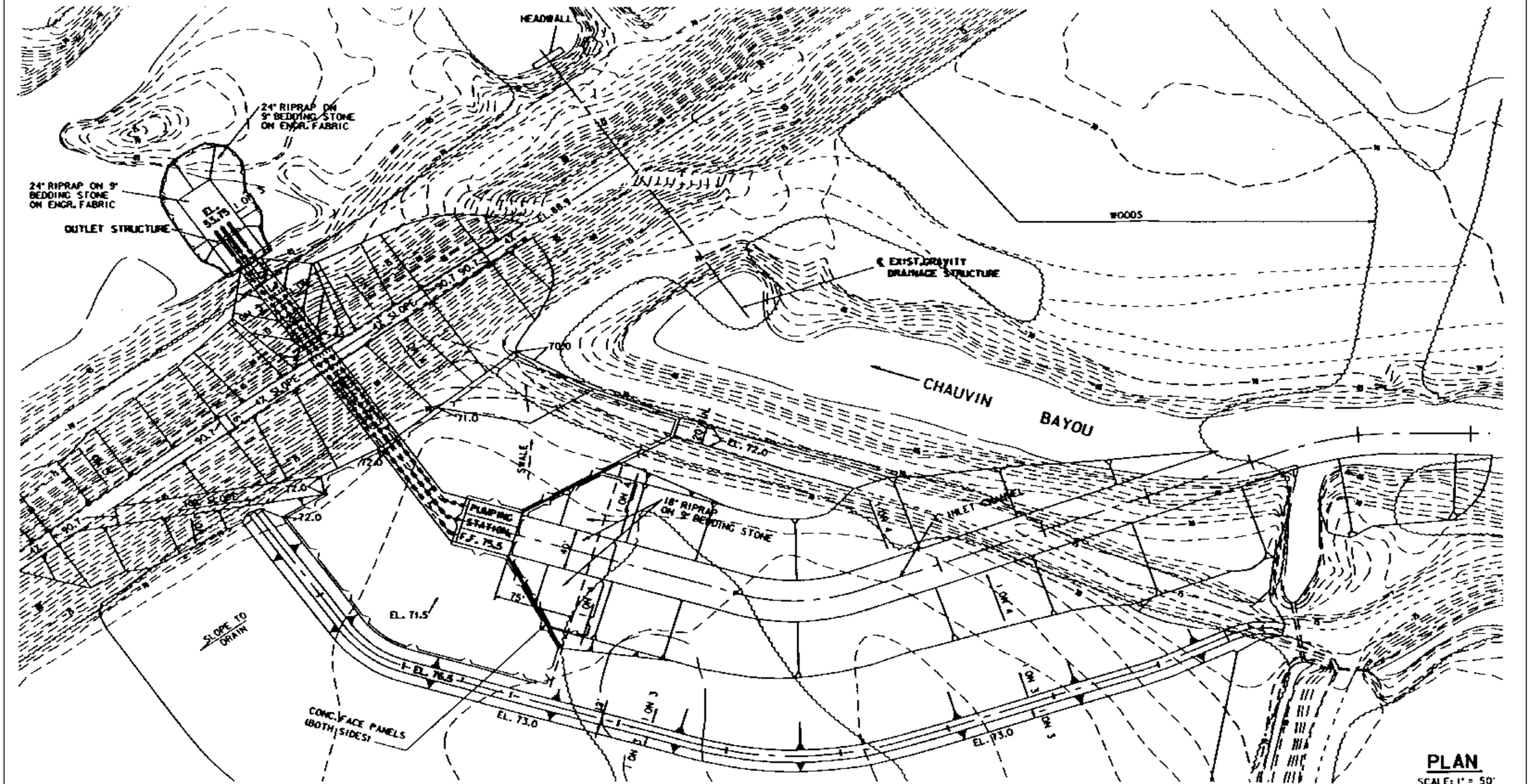

ROOF ACCESS
ROOF VENTILATOR
480V SWITCHGEAR
METAL ROLLING DOOR
PUMP JUNCTION BOX
GATE OPERATOR
MECHANICAL TRASH RAKE
NOTE: PUMP ACCESS PLATE AND GUARDRAILS SURROUNDING THE PUMP ACCESS HATCH NOT SHOWN
STAFF GAGE
PUMP DISCHARGE PIPE
NOTE: PUMP DISCHARGE PIPE SUPPORTS NOT SHOWN
POWER AND CONTROL CABLES
SUMP INTAKE GATE
BULKHEAD RECESS
SUMP INTAKE
INTAKE DIFFUSER
80°
8°

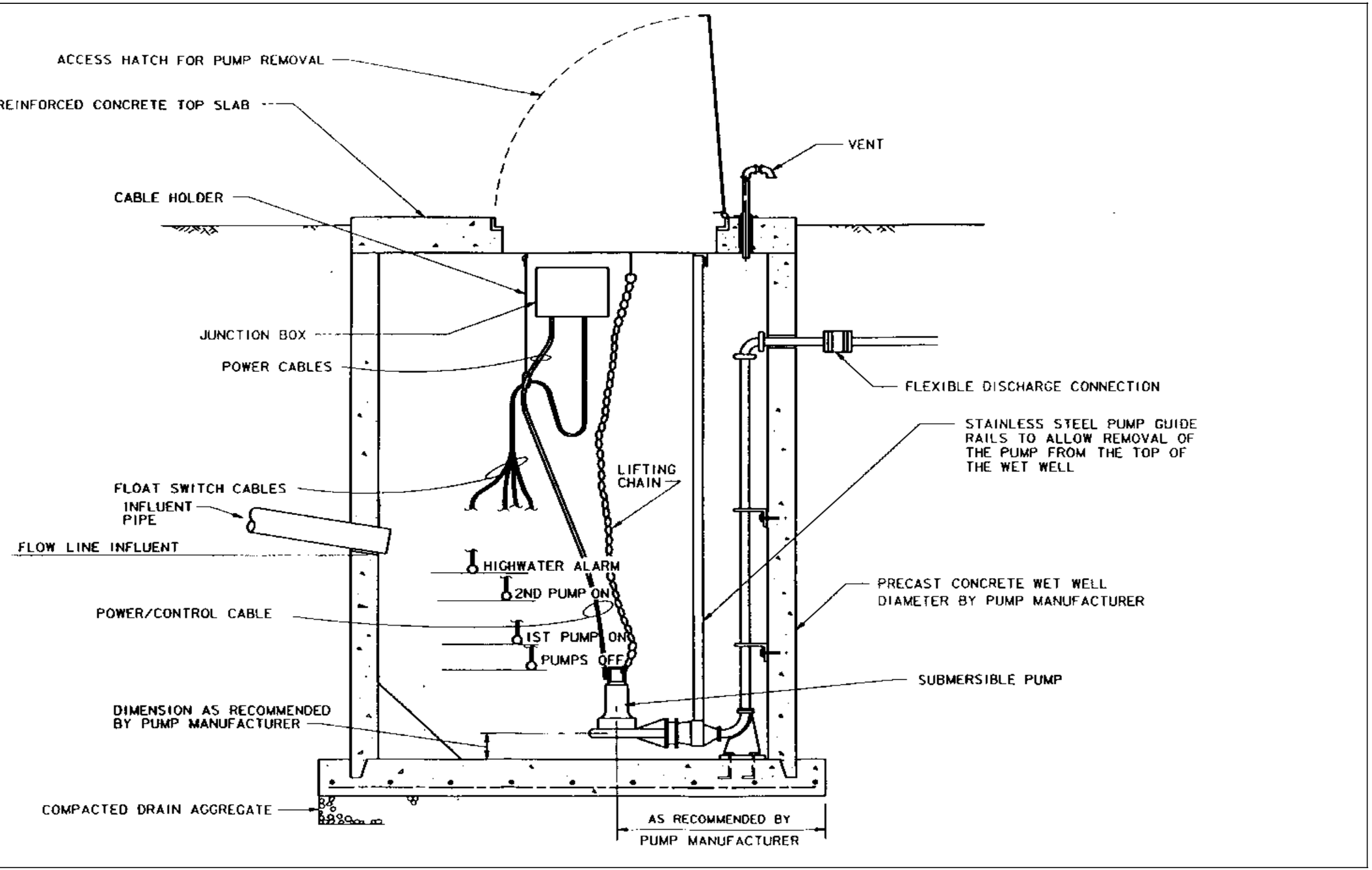
SECTION A-A


ROOF VENTILATOR
180 DEG. ELBOW
OVERHEAD CRANE
DISCHARGE CHAMBER
VENT PIPE
STOPLOG SLOT
ROLLING DOOR
SUMP AREA ACCESS
SUMP VENT OPENING
MECHANICAL TRASH RAKE
PARAPET WALL
GUARDRAIL
MOTORIZED GATE STEM OPERATOR
FLAP GATE
CATWALK
THE FSI CAN ALSO BE STEEL EMBEDDED IN CONCRETE OR FORMED IN CONCRETE.
SUMP CLOSURE GATE
GRAVITY DRAIN
GRAVITY DRAIN
FORMED SUCTION INTAKE
MAINTENANCE BULKHEAD SLOT
GROUT
FLOW


EXISTING MAIN DRAINAGE CHANNEL
℄ GRAVITY DRAINAGE CHANNEL
℄ GRAVITY DRAINAGE CHANNEL ACCESS ROAD
℄ NORTH CHANNEL ACCESS ROAD
DISCHARGE CHAMBER
PUMP STATION
℄ PUMP STATION ENTRANCE ROAD
300'
℄ PUMP STATION ENTRANCE CHANNEL
PARKING AREA
426
426
430
435
440
445
446
445
440
℄ LEVEE & GRAVEL ROAD
EMERGENCY CLOSURE STRUCTURE
2-60" DISCHARGE CULVERTS
430
420
OUTLET STRUCTURE
410


LEVEE ℄
SIPHON BREAKER ENCLOSURE
SAXOPHONE DISCHARGE
DRAIN PIPE
STONE PROTECTION
PILES
PIPE SUPPORT
DISCHARGE PIPE
FLEXIBLE COUPLINGS (TYP.)
* - THIS DISTANCE SHALL BE NO GREATER THAN 5'-0"


HEADWALL
24" RIPRAP ON 9" BEDDING STONE ON ENGR. FABRIC
24" RIPRAP ON 9" BEDDING STONE ON ENGR. FABRIC
OUTLET STRUCTURE
EL. 88.9
WOODS
EXISTING DRAINAGE STRUCTURE
CHAUVIN
BAYOU
47% SLOPE
70.0
71.0
72.0
PUMPING STATION F.F. 75.5
18" RIPRAP ON 9" BEDDING STONE
INLET CHANNEL
EL. 71.5
SLOPE TO DRAIN
EL. 76.5
CONC. FACE PANELS (BOTH SIDES)
EL. 73.0
EL. 73.0
PLAN
SCALE: 1" = 50'


ACCESS HATCH FOR PUMP REMOVAL
REINFORCED CONCRETE TOP SLAB
VENT
CABLE HOLDER
JUNCTION BOX
POWER CABLES
FLEXIBLE DISCHARGE CONNECTION
STAINLESS STEEL PUMP GUIDE RAILS TO ALLOW REMOVAL OF THE PUMP FROM THE TOP OF THE WET WELL
LIFTING CHAIN
FLOAT SWITCH CABLES
INFLUENT PIPE
FLOW LINE INFLUENT
HIGHWATER ALARM
2ND PUMP ON
POWER/CONTROL CABLE
1ST PUMP ON
PUMPS OFF
PRECAST CONCRETE WET WELL DIAMETER BY PUMP MANUFACTURER
SUBMERSIBLE PUMP
DIMENSION AS RECOMMENDED BY PUMP MANUFACTURER
COMPACTED DRAIN AGGREGATE
AS RECOMMENDED BY PUMP MANUFACTURER