

**CITY OF HOUSTON DEPARTMENT
OF PUBLIC WORKS AND
ENGINEERING**

**ENGINEERING DESIGN MANUAL
FOR
SUBMERSIBLE LIFT STATIONS**



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SECTION 1
INTRODUCTION

SECTION 1 INTRODUCTION

1.1 Purpose

This Manual provides guidance and design criteria for use by Design Engineers developing site-specific drawings for new lift stations. The Design Guideline Drawings for Submersible Lift Stations are to be used with this manual as applicable. The purpose of these documents is to provide facilities that are consistent in quality and arrangement, throughout the City of Houston service areas. Any variance from this manual will be approved by the City Engineer.

1.2 Coordination with Other Documents

In addition to this manual and the Design Guideline Drawings, the Design Engineer should be familiar with the Design Guidelines for Lift Stations and Force Mains, Equipment Prequalification, and the City of Houston Standard Technical Specifications for further design criteria or other requirements that may be applicable to a specific project.

1.3 Responsibility of Design Engineer

The overall responsibility of the Contracted Design Engineer is to select the Design Guideline Drawings that are applicable to a specific lift station design and modify the drawings as required. A list of specific design and other requirements that would be the responsibility of the Design Engineer includes, but is not limited to, the following tasks:

1.3.1 The Design Engineer shall use the latest City of Houston Submersible Lift Station Design Guidelines and Drawings.

1.3.2 Provide control building for 3-pump lift stations with pump rating of 50 horsepower or greater..

1.3.3 Determine which station configuration is required: Preferred, Secured Site or Exposed Site.

1.3.4 Perform hydraulic calculations and develop system curves to determine sizes and quantities of the following:

1.3.4.1 Pumps and motors (identify acceptable models from at least three Prequalified manufacturers)

1.3.4.2 Discharge piping and valves

1.3.4.3 Header and force main

- 1.3.5 Determine necessity of and/or sizes for:
 - 1.3.5.1 Surge relief valve(s) - If surge relief valve is required provide analysis in the Final Engineering Design Report for justification.
 - 1.3.5.2 Air release valve - An air release valve is required on all lift stations.
 - 1.3.5.3 Air and vacuum valves
- 1.3.6 Determine piping size for wet well ventilation.
- 1.3.7 Determine size for valve vault ventilation fan(s) and air duct(s), if required.
- 1.3.8 Determine depth of wet well and wet well volume as it relates to pump controls.
- 1.3.9 If a control building is used, determine the required length and verify or adjust the structural design, as necessary. Review CTE design calculations for the control building to verify adequacy and applicability to the project specific requirements. Provide revised or original calculations as needed to tailor to the specific project. This is required to allow placing of the design engineer's registration stamp on the Drawings. Include design criteria and assumptions on the Drawings sufficient to obtain building permits.
- 1.3.10 Review CTE design calculations for the wet well top slab (entire structure for 2-pump small lift stations) and valve vault (when used) to verify adequacy and applicability to project specific requirements. Provide revised or original calculations as needed to tailor to the specific project. This is required to allow placing of the design engineer's registration stamp on the Contract Drawings.
- 1.3.11 Complete structural design for wet well walls and base slab. Provide buoyancy calculations.
- 1.3.12 Caisson and/or open cut types of construction should be designed and shown on the Contract Drawings. .
- 1.3.13 Provide a complete listing of the structural design criteria for the lift station and any other related structures. The criteria should include materials, loadings and load combinations, major design assumptions, and design approach. These criteria should be included as an appendix to the Final Engineering Design Report.
- 1.3.14 Obtain 2-year electrical service records from Utility Service Provider. . Calculate the required storage capacity as defined by 30 TAC.217 and determine measures required to meet power reliability standards.
- 1.3.15 Complete and/or augment conduit and device rating schedules as necessary for specific project requirements. Determine service size from the latest Guideline Drawings. Obtain available fault current from Utility Service Provider and calculate

fault ratings. Determine need for and size of power factor correction capacitors.

- 1.3.16 Coordinate with the City's project manager to initiate electrical service/application.
- 1.3.17 Provide all details for site pavement cross-section, joints, connection to existing pavement, curbs, sidewalks, etc. Control and/or expansion joints shall be shown located to reduce the potential for cracking.
- 1.3.18 Remove all notes to Design Engineer (shown in Italics) from the Contract Drawings. Provide all information shown as *TBD* or as otherwise instructed in notes to Design Engineer. Revise sheet numbers, title block information, etc. as appropriate for specific project contract drawing package. See Appendix "A", Figure A-5, for a general example.
- 1.3.19 Dimensions on the Guideline Drawings which are modified by "max" or "min", but which need to be selected, as a definite dimension by the design engineer should have the appropriate dimension listed without the modifier.
- 1.3.20 Complete additional designer responsibilities as described in this manual.
- 1.3.21 Provide Odor Control facilities if required.
- 1.3.22 Edit and supplement the City of Houston Standard Technical Specifications as needed to apply to the specific project. Delete or indicate as "Not Applicable to this Project" where materials or equipment included in the specifications is not used for the specific project.
- 1.3.23 Comply with the Landscaping requirements of City of Houston Ordinance No. 91-1701.
- 1.3.24 Sign and seal final Contract Documents including Guideline Drawings modified or otherwise included in the Contract Drawings.
- 1.3.25 Provide hydraulic analysis, if required, to justify use of baffle walls in the wet well.

SECTION 2
CIVIL DESIGN CRITERIA

SECTION 2 CIVIL DESIGN CRITERIA

2.1 Description and Design Criteria for Submersible Lift Stations

2.1.1 The physical dimensions and range of design capacities of the Lift Stations are shown in the following Table 1.

Lift Station Configuration
Pump Ranges, Capacity Ranges, Discharge Piping, Wet Well Size and Site Size

Number of Pumps	Individual Pump Capacity – GPM		Lift Station Firm Design Capacity – GPM		Pump Discharge Piping - Inches		Minimum Wet Well Diameter - Feet	Minimum Site Size
	From	To	From	To	From	To		
2	0	199	0	199	4	4	6' – 0"	55' x 55'
2	200	499	200	499	4	8	8' – 0"	55' x 55'
2	500	999	500	999	8	10	10' – 0"	70' x 70'
3	250	500	500	999	6	10	10' – 0"	70' x 70'
3	500	999	1000	1998	8	10	12' – 0"	75' x 75'
3	1000	1399	2000	2798	10	12	14' – 0"	75' x 75'
3	1400	1999	2800	3998	12	16	16.5' – 0"	75' x 75'
3	2000	3499	4000	7198	16	24	21' – 0"	85' x 85'
4	800	3499	2400	10,497	10	20	21' – 0"	85' x 85'
5	2500	3999	7500	15,996	18	20	25' – 0"	85' x 85'
6	3000	5299	15,000	21,196	18	20	28' – 0"	90' x 90'

Note: This table has not been coordinated with the City of Houston Design Guideline Drawings for Submersible Pump Lift Stations dated 1996. These drawings are currently being revised and will be issued at a later date.

2.1.2 The physical dimensions of the wet well and valve vaults were sized to accommodate the maximum pipe and valve sizes required to pump the maximum range of pumping capacities per pump for each standard station as listed in Table 2.1.

2.2 Loadings and Clear Opening Dimensions for Hatches and Gratings

2.2.1 Pump and valve vault hatches and valve vault grating shall be designed for 150-psf live loading. FRP grating in standard 48-inch (or less) panel widths shall be used. Provide galvanized steel support beams where required, space to avoid interference with access to valves or other mechanical items from above.

- 2.2.2 The clear opening dimensions of the hatches for each Lift Station are shown on the Design Guideline Drawings.
- 2.2.3 The Design Engineer shall verify the size and location of the hatch openings based on the selected pump size and manufacturer as well as the selected hatch manufacturer.
- 2.2.4 The clear opening is area available to lift out pumps or valves when the hatch is open. This area is smaller than the concrete opening in the top slab or the area using the inside dimension of the frame. The reinforcement for the under side of the hatch cover reduces the clear opening of the frame.
- 2.3 Valve Vault Dimensions and Pump Spacing: The dimensions of the valve vaults associated with each standard station are based on OSHA standard clearances from entrance ladders, piping, valves, and walls or beams.
 - 2.3.1 Ladder Dimensions: Minimum ladder width equals 16 inches. Minimum ladder clearance is as follows:
 - 2.3.1.1 Width: Centerline of ladder to edge of adjacent wall, valve, piping, or hatch clear opening equals 15 inches.
 - 2.3.1.2 Toe Depth: Centerline of ladder rungs to wall, grating support, or hatch clear opening equals 7 inches.
 - 2.3.1.3 Body Depth: Centerline of ladder rungs to wall, valve, piping, or hatch clear opening equals 30 inches.
 - 2.3.2 Valve Vault Head Clearance: Minimum vertical distance from valve vault floor or grate walking surface to bottom of top slab or beam equals 6 feet - 8 inches minimum. Open-air valve vaults with grating over them must have enough depth for the air release valve(s) to fit on top of the discharge header and beneath the grating (a minimum vertical distance of 3' - 0").
 - 2.3.3 Valve Vault Pipe Spacing: Minimum spacing between valve vault piping is based on OSHA requirements and 11 inches minimum between hatch openings. Dimensions shown on the Guideline Drawings are based on the following assumptions:
 - 2.3.3.1 Two (2) Pumps with 8" discharge piping: Minimum spacing of 18 inches plus twice (2X) the smaller centerline to outside edge dimension of the largest recommended check valve, which is 35 inches.
Note: The two-pump station requires one (1) reverse arm check valve in order to maintain the minimum clearance of 18 inches.
 - 2.3.3.2 Three (3) or four (4) Pumps with 12" discharge piping: Minimum spacing of 18 inches plus the total width of the largest recommended check valve equals 57 inches.

- 2.3.3.3 Three (3) or four (4) Pumps with 20" discharge piping: Minimum spacing of 18 inches plus the larger centerline to outside edge dimension of the largest recommended check valve equals 70.5 inches.
- 2.3.4 Pump Spacing: Minimum spacing between the wet well pumps is directly related to the centerline spacing of the valve vault discharge piping. This spacing is to be verified by the design engineer in accordance with selected pump manufacturer's recommendations for proper pump operation.
- 2.4 Force Main Size and Pump Station Configuration Selection
 - 2.4.1 Force main size and pump station configuration should be based on sound engineering judgment and criteria provided below. Confirm all size and configuration selections with the City of Houston project manager and Wastewater Operations.
 - 2.4.2 The selection of the force main size is based on the velocity of minimum and maximum pumping volumes and the heads generated. The velocities in the force main should be a minimum of 3 fps for minimum flow and a maximum of 8 fps for maximum flow. Force main velocities higher than 6 fps should be checked for possible high and low negative surge pressures during a power failure when all running pumps will stop suddenly. See Section 2.12 "Surge Pressures In a Force Main" for discussion.
 - 2.4.3 A wider range of force main velocities may be considered where there is a high variance between normal dry weather flow and peak wet weather flow. Minimum dry weather discharge velocity should not be less than 2.5 fps, and maximum velocity not greater than 9 fps.
 - 2.4.4 In order to accommodate wet and dry weather flow variations of approximately a maximum 4:1 ratio, the number of pumps selected must be analyzed. In general, an increased number of pumps should be used as the variance between wet and dry weather flows increases.
 - 2.4.5 The total number of pumps should be based on the largest pump as a standby. Therefore, a 4-pump station configuration with 4-1000 gpm pumps will have a design firm station capacity of approximately 3000 gpm.
 - 2.4.6 An example for selection of force main size and a 3 pump or 4 pump station configuration with a maximum design flow of 4.2 mgd is as follows:

Trial No. 1 - Use 16 - inch force main
 4 pump station = 3 pumps @ 1.4 mgd - min. vel. one pump = 1.55 fps
 3 pump station = 2 pumps @ 2.1 mgd - min. vel. one pump = 2.3 fps
 Total flow 4.2 mgd max. vel. = **4.65 fps**

Trial No. 2 - Use 14 - inch force main
 4 pumps station = 3 pumps @ 1.4 mgd - min. vel. one pump = 2.76 fps
 3 pumps station = 2 pumps @ 2.1 mgd - min. vel. one pump = 3.2 fps

Total flow 4.2 mgd max. vel. = **8.8 fps**

2.4.7 The selection of the pump station configuration and force main size would be for a 3-pump station with a 14-inch force main. The velocity in the 16-inch force main with 3 pump or a 4 pump station would be too low, and the velocity in the 14-inch force main for either a 3 pump or a 4 pump station @ 8.8 fps would be within recommended criteria for the total flow of 4.2 mgd.

2.5 Pump Selection

2.5.1 The section above establishes the number of pumps and the capacity required to meet total design conditions. Once the number of pumps and the flows have been determined, a system head curve as detailed in the Section 2.10 must be completed. This system head curve will establish the actual flow of the selected pumps and motors operating individually or in combination with the other pumps when pumping against a variable friction head in the force main. The selection of the pump and motor must be based on pump manufacturer's pump curves as shown in Figure 2 and the following considerations relative to efficiency and pumping costs.

2.6 Efficiency and Pumping Cost

2.6.1 If the system head curve is rather flat, consisting of mostly static head, pump selection becomes unimportant as far as operating power cost is concerned. This can be explained using the following equation:

$$\text{Cost of pumping 1000 gallons} = (\text{TDH} \times \text{Cents/KWH}) / \text{Eff} (\%) \times 3.185$$

2.6.2 If the station system head (TDH) is assumed to be a constant value which is equal to the static head in this case, then the cost of pumping 1000 gallons will not change whether it is pumped at a rate of 500 gpm for 2.0 minutes or it is pumped at the rate of 1000 gpm for 1.0 minute assuming either pump is equally efficient at the respective operating capacity.

2.6.3 However, if the TDH is due mainly to frictional head loss with little or no static head, the operating power cost of a 1000 gpm pump will be 4 times as high as that of a 500 gpm pump, since the TDH of the pump is directly in proportional to the square of the operating capacity.

2.6.4 Taking the pump efficiency factor at different operating capacity points into consideration the cost of operating a pump at 1000 gpm may be more than 4 times as great. It is therefore important to avoid over sizing a pump when one half of pump size will meet the average requirement.

2.6.5 When two or more pumps operate together for the maximum flow condition care should be taken to insure that each pump will not operate near the shut-off point. For best results pumps should not be operated at less than 50% of the best efficiency point capacity nor be extended to beyond 120% of that capacity. This

requirement may be achieved by changing the pump selection, or the force main size, or both.

2.7 Prequalified Pump Manufacturers

2.7.1 Refer to City of Houston Technical Specifications for manufactures prequalified to provide pumps, motors and appurtenances for City of Houston projects. During final design, the design engineer should confirm that at least three prequalified manufacturers can meet the specified conditions.

2.8 Force Main Discharge Manhole

2.8.1 To reduce hydrogen sulfide generation at the discharge end of force main, the discharge flow inside the discharge manhole should be steady, non-turbulent by setting the top of force main pipe to match the average flow depth inside the receiving sewer pipe. A new manhole receiving a force main discharge must be specified and shown on the drawings as a "corrosion resistant manhole".

2.9 Receiving Sewer

2.9.1 The receiving sewer should be designed to handle the maximum pump discharge without surcharge. If two or more pump stations are served by one single sewer pipe, the probable maximum operating capacity of two stations combined should be determined.

2.9.2 Unless the sewer line is long, grade is flat and over sized, there will not be enough storage capacity inside the sewer to smooth out the peaks of two pump stations when they are operated at the same time. Under these conditions the sewer as well as pumps down stream of it, should be designed for the total capacity of two pump stations.

2.10 Example of Construction of System Head and Pump Capacity Curves to Determine Actual Pump Operating Capacities

2.10.1 The selection of the pumps is based on the analysis of system head and pump capacity curves, which determine the pumping capacities of the pumps operating alone and with the other pumps as the total dynamic head increases due to additional flow pumped through the force main.

2.10.2 Piping head losses should be calculated in accordance with the Hydraulic Institute Standards in connection with head losses through lift station piping and valves.

2.10.3 The C factors used in calculation of friction head losses should be based on both a C of 120 and C of 140. The pumps should be able to perform between the heads generated between these C factors.

2.10.4 The pump motors should be non-over loading over the entire range of pumping, including the ability to pump into the force main under a flooded wet well condition.

The water surface elevation for the flooded condition would be the rim of the lowest adjacent manhole, or the underside of the top slab, which is lower.

2.10.5 Refer to the section on Pump Design Conditions in the Design Guidelines Manual For Lift Stations and Force Mains.

2.10.6 This example of the system head and pump capacity curves is based on the following conditions:

- Force main = single and twin 26-inch force mains
- Length = 15,500 LF
- Total flow \pm 20.5 mgd
- Total gpm = $20,500,000 \div 1440 = 14,236$ gpm
- No. of pumps = 4 assuming one pump as standby
- Minimum gpm per pump = $14236 \div 4 = 3559$ gpm
- Select 4 - 5000 gpm pumps

2.10.7 Pump Curves

2.10.8 The pump performance curves represent the volume of liquid that can be pumped with a specified pump and impeller under a range of head conditions. The pump performance curves for the 5000-gpm pump used in this example are shown in Figure 1. It shows the gpm pumped in relation to the various head conditions and best efficiency point with impeller 510 and is tabulated as follows:

<u>GPM</u>	<u>Head</u>
0	124
1500	108
3000	93
4500	78
6000	63
7500	48
9000	33

2.10.9 The above values are plotted in Figure 2 and represent the pump capacity curve for a single pump.

2.10.10 Plotting Multiple Pumping Capacity Curves

2.10.11 The values for multiple pump capacities are also shown in Figure 2. These values are arrived at by constructing the 2nd and 3rd pump capacity curves as a multiple of the Pump No. 1 curve as shown in Figure 3:

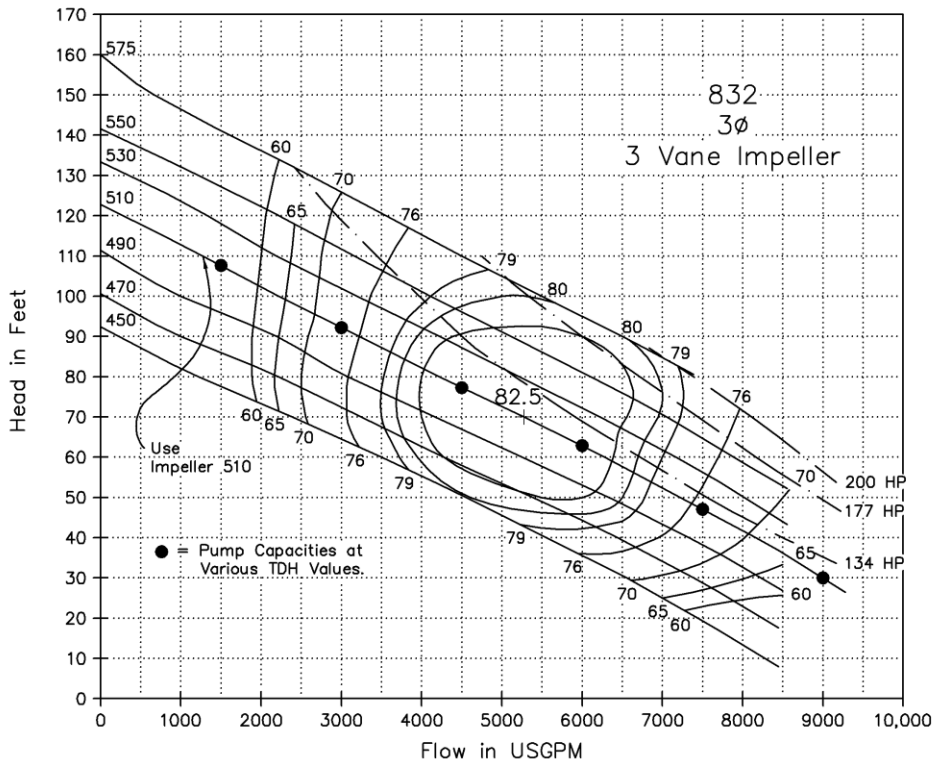


Figure 1
Pump Performance Curve

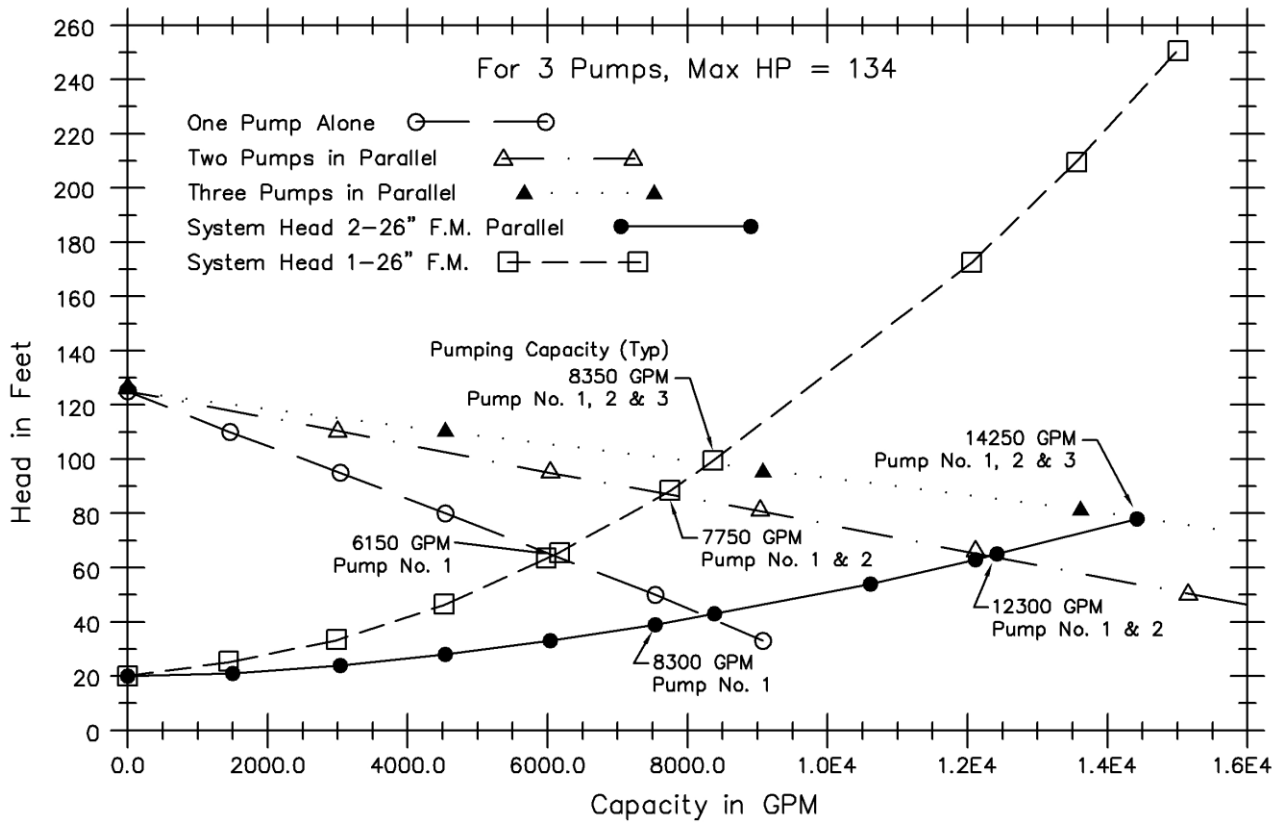


Figure 2
System Head & Pump Capacity Curve

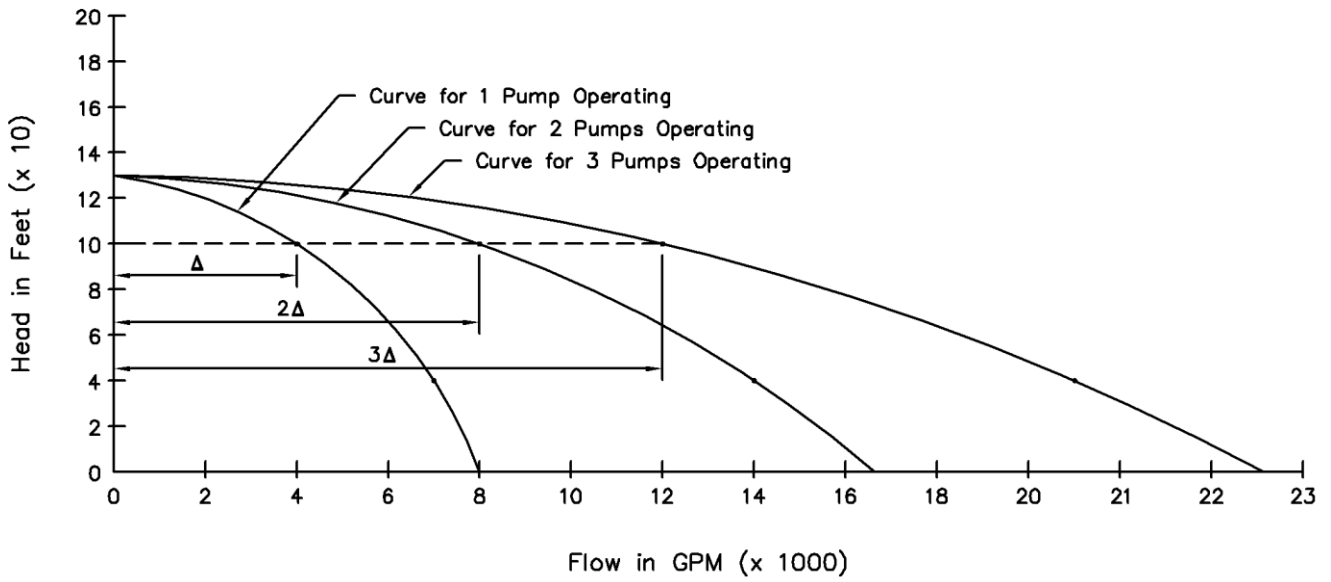


Figure 3
Typical Construction of Multiple
Pump Operating Curves

2.10.12 System Head Curve

2.10.13 The system head curve represents the TDH generated by a variety of flows through the proposed or existing force main and includes the static head. As the flows through the force main increase the TDH also increases.

2.10.14 The heads generated through the twin 26-inch force main are as follows:

<u>Flow Through Force Main in GPM</u>	<u>TDH In Feet</u>
0	21
1500	21
3000	24
4500	28
6000	33
7500	39
8300	43
10,500	54
12,000	63
12,300	65
14,250	79

2.10.15 The heads generated through a single 26-inch force main are as follows:

<u>Flow Through Force Main in GPM</u>	<u>TDH In Feet</u>
0	21
1500	24
3000	32
4500	45
6000	63
7500	65
8300	88
10,500	98
12,000	172
12,300	209
14,250	250

2.10.16 The values of the twin and single 26-inch force main are plotted on the system head and pump capacity curves as shown in Figure 2. Represents the system head curves for the single 26-inch force main and for the twin 26-inch force mains.

2.10.17 Determine System Pumping Capacities For Multiple Pumps

- 2.10.18 The actual pumping capacities are determined by the intersection of the system head curves for single and twin 26-inch force mains with the pump capacity curves as shown in Figure 2.
- 2.10.19 The system pump capacities based on pumping into the single or twin 26-inch force main are shown as follows:

<u>No. of Pumps</u>	<u>Capacity Increase GPM</u>	<u>Total Pumping Capacity in GPM</u>	<u>TDH</u>
1	6150	6150	65
2	1600	7750	88
3	600	8350	98

<u>No. of Pumps</u>	<u>Capacity Increase GPM</u>	<u>Total Pumping Capacity in GPM</u>	<u>TDH</u>
1	8300	8300	43
2	4000	12300	65
3	1950	14250	79

2.10.20 The above values illustrate the wide range of the 5000-gpm pump over the range of system head conditions. A single pump ranges from 6150 to 8300 gpm. The maximum required total pumping rate of 20.5 mgd or 14,236 gpm is achieved by three pumps pumping into the twin 26-inch force main @ a maximum rate of 14250 gpm.

2.11 Wet Well Design

2.11.1 The wet well top slab shall be in compliance with “Rules and Regulations for Chapter 19, Guidelines Houston City Code Floodplain”, latest revision.

2.11.2 Minimum Wet Well Volume

2.11.2.1 The minimum required volume of wet well storage occurs when the flow into the wet well is one half the maximum inflow. In order to calculate this volume a minimum cycle time between starts of 6 minutes should be used for motors less than 50 H.P. so that the motor will have a maximum of 10 starts per hour. The cycle time for pump motor horse power between 50 and 100 H.P. should be 10 minutes and the cycle time for pump motors over 100 H.P. should be 15 minutes. The formula for minimum wet well volume is:

$$V = (T_{\min} \times Q_P) / (4 \times 7.5 \text{ gal/cf})$$

Where: T_{\min} = minimum cycle time in minutes
 Q_P = pump capacity in gpm
 V = volume in cubic feet

2.11.2.2 An example calculation to determine the minimum wet well volume is provided below. This example illustrates the wet well volume requirements for a 4 pump station using the following parameters:

- Max flow = 2370 gpm or 3.41 mgd
- No. of pumps = 4
- Pump capacities = 4 @ 800 gpm
- Cycle time = 6 minutes
- 12-inch force main, 1600 feet long
- Wet well surface area = 120 sf

2.11.2.3 The first step would be to develop a system head curve, which will show the actual pumping capacities, based on the variable friction heads generated in the force main as each pump is turned on. Based on the system head curve pump No. 1 would pump 1080 gpm, pump No. 1 and 2 would pump 1980 gpm, and pump No. 1, 2 and 3 would pump 2370 gpm. Pump No. 4 is a standby.

2.11.2.4 The wet well volume and corresponding pumping range in feet to accommodate the 6 minute cycle for each pump as they are turned on is:

$$\text{For Pump 1, } V-1 = \frac{6.0 \text{ min.} \times 1080 \text{ gpm}}{7.48 \text{ gpm/cf} \times 4} = 217\text{cf, } H_1 = 1.8'$$

$$\text{For Pump 2, } V-2 = \frac{6.0 \text{ min.} \times (1980-1080)}{7.48 \text{ gpm/cf} \times 4} = 180\text{cf, } H_2 = 1.5'$$

$$\text{For Pump 3, } V-3 = \frac{6.0 \text{ min.} \times (2370-1980)}{7.48 \text{ gpm/cf} \times 4} = 78\text{cf, } H_2 = 0.7'$$

$$\text{Total Wet Well Volume} = 475\text{cf, Total H} = \pm 4'$$

2.11.2.5 The following Table 2 shows the water levels (WL), and the heights (H) that water level rises or falls between pump stop and start, and indicates the pump status (either off or on).

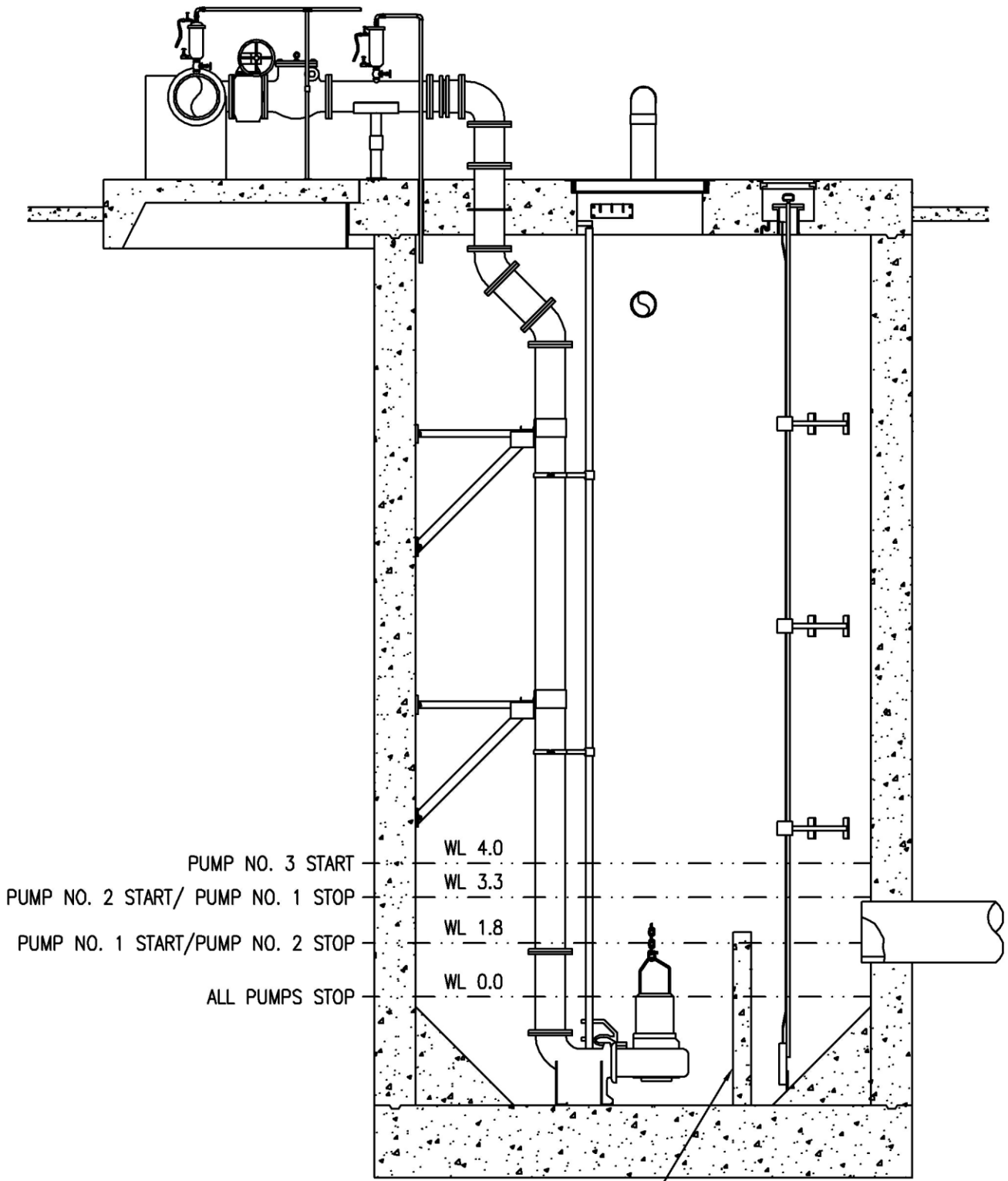
Table 2

PUMP CONTROL SCHEDULE EXAMPLE

<u>WL Elev.</u>	<u>Δ H</u>	<u>Rising Water Level</u>		<u>Falling Water Level</u>	
		<u>Action</u>	<u>Pump Station</u>	<u>Action</u>	<u>Pump Status</u>
4.00	-	P-3 on	P-1, P-2 & P-3 on	-	P1, P-2 & P-3 on
3.30	0.7	P-2 on	P-1 & P-2 on	P-1 off	P-2 & P-3 on
1.80	1.5	P-1 on	P-1 on	P-2 off	P-3 on
0.00	1.8	-	All Stop	P-3 off	All Stop

2.11.2.6 A typical section showing the start and stop control levels in a wet well is shown in Figure 4 on the following page.

2.11.3 Interior wet well design. Determine the required size for the ports in the baffle wall. The dimensions of the ports should be stated on the structural drawings. Size ports such that the velocity through all ports at firm station capacity is greater than 4.5 fps and less than 6.5 fps.



Baffle wall to be used only if required by hydraulic analysis.

Figure 4
 Typical Wet Well Elevation Showing Pump Control Levels

2.12 Surge Pressure in a Force Main: Surge pressure or "Water Hammer" in a force main is created by any change from a steady state flow condition, and may range from only slight pressure and/or velocity changes to sufficiently high vacuum or pressure conditions which may cause the collapse or rupture of the pipeline, or cause damage to pumps and/or valves. Water hammer is typically caused by the opening, closing or regulating of valves; or by the starting and/or stopping of pumps. The magnitude of the surge pressure created is a function of the following:

1. A change in the velocity of flow.
2. The density of the fluid.
3. The speed of the pressure wave within the fluid and piping system.

2.12.1 Velocity of Pressure Wave: The speed or velocity of the pressure wave is a function of the following factors:

1. Pipeline material (steel, cast iron, ductile iron, plastic, etc.)
2. Pipeline wall thickness
3. Pipeline diameter
4. The specific gravity and bulk modulus of the fluid being pumped.

The relationship of these various factors is expressed in the following equation:

$$a = \sqrt{[1 \div (w/g) * (1/K + D/e * C_1/E^1)]}$$

Where: a = Pressure wave speed, expressed in feet per second (ft/sec)

D/e = A dimensionless ratio of the pipeline diameter to its wall thickness.

E¹ = Young's Modulus of Elasticity for the pipeline material, expressed in pounds per square foot (lb/sf) and which for steel pipe is 4,390,000,000 lb/sf; for cast iron pipe is 1,730,000,000 lb/sf; and for ductile iron pipe is 3,456,000,000 lb/sf.

K = Bulk Modulus of water, expressed in lb/sf and which is 43,200,000 lb/sf at 20° C.

w/g = Mass density of water, expressed in slugs per cubic foot which is 62.4/32.2 = 1.938 slugs/cf.

C₁ = Coefficient of pipe support condition, which is dependent on Poisson's ratio (mu), which for most pipe materials the accepted mu = 0.3.

Note: The usual range of C₁ is 0.85 to 1.25 and is determined as follows:

C₁ for a pipe anchored at one end only, while the other end is

$c_{free} = 5/4 - \mu = 0.95$.

C_1 for a pipe anchored at both ends = $1 - (\mu)^2 = 0.91$.

C_1 for a pipe anchored at both ends with an expansion joint between anchors = $1 - \mu/2 = 0.85$.

In addition, the pressure wave speed in water is usually in the range of 3000 to 4000 ft/sec, and using a value of 3500 ft/sec is generally sufficient for approximations.

2.12.2 Approximate Wave Speeds Examples Pipes: The following Tables 3, 4 and 5 show approximate wave speeds in various types of pipe based on the Modulus of Elasticity (E) as shown and Poisson's ratio (μ) at the value of 0.3.

TABLE 3

WAVE SPEED IN STEEL AND CAST IRON PIPES

D/e ratio	Wave Speed ft/sec.	
	Steel Pipe <u>E=30 X 10⁶psi</u>	Cast Iron Pipe <u>E=12 X 10⁶psi</u>
25	4250	3750
50	3900	3250
75	3600	2900
100	3400	2600
150	3000	2250
200	2750	2000

TABLE 4

WAVE SPEED IN HOBAS PIPES

D/e ratio	Wave Speed ft/sec.		
	Class 50 psi <u>E=0.5 X 10⁶psi</u>	Class 100 psi <u>E=1.2 X 10⁶psi</u>	Class 250 psi <u>E=2.8 X 10⁶psi</u>
12	1720	2450	3200
16	1510	2200	2950
20	1370	2000	2750
25	1230	1830	2550
50	890	1350	1950
75	730	1110	1640
100	630	970	1440

TABLE 5

WAVE SPEEDS IN OTHER PLASTIC PIPES

D/e ratio	Wave Speed ft/sec.	
	H.D. Polyethylene Pipe E=0.113 X 10 ⁶ psi	Other Plastic Pipe E=1.20 X 10 ⁶ psi
12	860	1130
16	750	990
20	670	890
25	603	800
50	428	570
75	350	460
100	300	400

2.12.3 Surge Pressure - Sudden Flow Stoppage: The magnitude of surge pressure per unit change in the velocity of flow is expressed by the following equation, for the sudden or instantaneous stoppage of flow:

$$h_w = av \div g$$

Where: h_w = pressure rise expressed in feet
 a = pressure wave speed expressed in ft/sec
 v = flow velocity of the pumped fluid in ft/sec
 g = 32.2 ft/sec²

Thus, if a liquid is flowing at a velocity of 10 ft/sec through a pipeline and is brought to a sudden stop, the increase in pressure, or surge pressure, using a pressure wave speed of 3500 ft/sec is determined as follows:

$$\begin{aligned} h_w = av \div g &= 3500 \text{ ft/sec} \times 10 \text{ ft/sec} \div 32.2 \text{ ft/sec}^2 \\ &= 35,000 \text{ ft}^2/\text{sec}^2 \div 32.2 \text{ ft/sec}^2 = 1087 \text{ ft} \\ 1087 \text{ ft} \div 2.31 \text{ ft/psi} &= 470.56 \text{ psi} \end{aligned}$$

2.12.4 Surge Pressure - Change in Flow: If the velocity of flow within the force main is changed, but not completely stopped, the surge pressure rise is expressed by the following equation:

$$h_w = a/g (v_1 - v_2)$$

Where: v_1 = original steady flow velocity expressed in ft/sec
 v_2 = final steady flow velocity expressed in ft/sec

Thus, if a liquid is flowing at a velocity of 8 ft/sec while being pumped by two pumps, then one pump is stopped resulting in a flow velocity of 4 ft/sec, the increase in pressure or surge pressure, using a pressure wave speed of 3500 ft/sec is determined as follows:

$$h_w = a/g (v_1 - v_2) = \frac{3500 \text{ ft/sec}}{32.2 \text{ ft/sec}^2} (8 \text{ ft/sec} - 4 \text{ ft/sec})$$

$$= 108.7 \text{ 1/sec} (4 \text{ ft/sec}) = 434.8 \text{ ft}$$

$$434.8 \text{ ft} \div 2.31 \text{ ft/psi} = 188 \text{ psi} \pm$$

It should be noted that as a "Rule of Thumb" the above equations, $h_w = av \div g$ and $h_w = a/g (v_1 - v_2)$, will yield a surge pressure of approximately 100 ft of water (43.3 psi) per each 1 fps change in velocity.

2.13 Comparison: Surge Analysis by Computer Program

It should be noted that the above equation represents the maximum surge pressure possible for a given situation. The equation works well for simple one-pipe situations where near instantaneous flow velocity changes occur. In more complex situations, such as pumping stations or pipe networks, the use of this equation may tend to predict excessive pressures. These predictions then often lead to over design of pumping stations, pipelines, etc., which unnecessarily drives up project costs.

A more detailed analysis using a computer model will often provide a lesser, but more accurate, design pressure and also provide insight into other potential problems such as minimum and negative pressures predicted as well as the potential cavitation locations within a pipeline. The more accurate design pressures may allow the designer to specify less costly materials while still maintaining an appropriate safety factor. In complex situations, the cost of a thorough computer analysis is usually justified by total project savings. An example comparing the two methods is given below:

Using the data for Example No. 1 (Section 2.15), the surge pressures predicted by the above equation are 294 psi.

By constructing a simple computer model, the predicted pressures drop to 230 psi.

By constructing a somewhat more complex computer model, the predicted pressures drop further to 137 psi.

2.14 Surge Pressure Considerations

2.14.1 Pipeline Length: For pipelines of infinite length, surge pressures resulting from variations in the velocity of flow through the pipeline are not affected in magnitude by the rate at which the velocity of flow is changed. However, this effect is not true in pipelines of finite length. This difference is significant in surge pressure phenomena in actual pipelines.

2.14.2 Wave Reflection: In actual pipeline situations, surge pressure problems can become somewhat more complex because the end of the pipeline institutes the mechanism of wave reflection. That is, when the pressure wave reaches the end of the force

main, it reverses direction and a wave of increased pressure travels back to the pumps or valve, where reversal of the pressure wave takes place again and a second pressure wave of reduced magnitude travels the length of the pipeline. This is repeated until steady state is reached.

- 2.14.3 Pipeline Friction: Pipeline friction helps to decelerate the pressure wave velocity, thus each time the pressure wave travels along the length of the pipeline in either direction, its velocity in the pipeline decreases. The change in velocity of the pressure wave is expressed by the following equation: $\Delta v = Gh/a$, where, h is the difference in head (pressure) at the two ends of the force main plus the friction head, at the average velocity of the pressure wave, during the passage of the wave.
- 2.14.4 Sudden Change in Flow Conditions: A change in flow conditions within a force main is considered to be "sudden" if the change is completed within the time required for the surge pressure wave to travel the length of the force main, be reflected, and return to the point of origin. This time period for the surge pressure wave to make a round trip is referred to as the "critical period" of the force main and is expressed by the equation $t = 2L/a$, where L = the distance between the point of flow change, i.e. pumps or valve, and the point of wave reflection. The maximum surge pressure occurs at the point of velocity change, regardless of the rate of change in velocity.
- 2.14.5 Gradual Change in Flow Conditions: A change in flow conditions with a force main is considered to be "gradual" if the change is completed in a period, which is greater than the "critical period". This scenario may be considered as a series of flow velocity changes, each produced in a time equal to or less than $2L/a$. For "n" increments of change in velocity within the initial period of $2L/a$:

1. The greatest incremental pressure change will result from the largest incremental change in velocity.
2. The total pressure change during the first interval of $2L/a$ will be the sum of the "n" incremental changes in pressure that occurred during the initial interval.

The maximum surge pressure change may, however, occur after the first $2L/a$ interval and should be determined from an accurate analysis of the direct and reflected impulses as performed by a graphical or computer model analysis.

- 2.14.6 Potential Severity of Surge Pressure: In assessing the potential severity of a possible surge pressure situation, it is necessary to determine whether the change in flow conditions are to be considered as "sudden" or "gradual". As an example, if the length of force main being considered is 1500 feet, the wave velocity is assumed to be 3500 ft/sec, the "critical period" is determined to be $2L/a = 2 \times 1500 \text{ feet} \div 3500 \text{ ft/sec} = 0.9$ seconds. Since it is practically impossible to intentionally produce a significant change in velocity within 1 second or less, in pipeline sizes typically encountered, the "sudden" change case most likely will not occur, and therefore maximum surge pressures are not likely to occur. This is very characteristic of "short" force mains and with the exception of possible slamming of check valves,

these force mains are seldom of concern, and would not require any surge relief valves or other devices.

On the other hand, as an example, if the length of force main being considered is say 20,000 feet, and the wave velocity is still assumed to be 3500 ft/sec, then the "critical period" is determined to be $2L/a = 2 \times 20,000 \text{ ft} \div 3500 \text{ ft/sec} = 11.4$ seconds. Under this scenario, a substantial change in the flow velocity can be achieved within this time and is likely to be of serious concern.

2.14.7 Probable Effects of Surge Pressure: The following brief discussion is presented to assist in ascertaining the probable effects of surge pressure by classifying the physical characteristics of the force main. Identification of the initial cause of the change in flow from the steady state must be made. The three most frequently encountered probable causes are:

1. The opening/closing of a valve.
2. The starting/stopping of a pump.
3. The failure of the force main.

Typically, the manual or automatic operation of valves cannot cause a "sudden" change in the flow conditions and cause a surge pressure of concern. Pumping systems, however, are more often of a more serious concern and typically have two types of problems associated with them:

1. The starting/stopping of the pumps under normal operating conditions.
2. The pump operation under power failure conditions.

Under normal operating conditions the change in flow conditions are typically controlled by valves in the pump discharge line, and may be considered as a control valve condition, which would not cause a "sudden" change in the flow condition or cause a surge pressure of concern.

In a power failure condition the pumps may initiate and cause a surge pressure. If the probable effect of surge pressure is serious, according to the criteria presented above, a detailed analysis by experts is recommended.

Additionally, if a pump discharge valve closes "suddenly", before the forward movement of the water column stops, cavitation of the water column may occur. Cavitation may also occur at high points in the force main during the initial phases of pressure loss in the system. Vapor cavities formed under these conditions are typically closed with violent impact upon reversal of the flow and can result in extremely high surge pressures. The analysis of surge pressures associated with cavitation requires a detailed computer analysis.

Likewise, a failure of the force main can cause complex surge pressures the analysis of which would best be accomplished by performing a detailed computer analysis by an expert in the field.

2.14.8 Classification of Pumping Systems: Table 6 is a simple classification of pumping systems into two categories "A" and "B". Surge problems occurring under category "A" situations are typically of minor concern and usually occur with great frequency in actual practice. The severity of the surge problems associated with the category "A" situations may be determined from the checklist presented as Table 7.

TABLE 6

CLASSIFICATION OF FORCE MAINS IN PUMPING SYSTEMS

1. Type of System	A	B
A. Single pipeline of uniform size	X	
B. Single pipeline of more than one size		X
C. Two or more parallel lines		X
D. Single or parallel system connected to a distribution grid		X
2. Profile of System		
A. Relatively flat or gradual ascending slope	X	
B. Steep slope (length less than 20 times the pump head)		X
C. Intermediate high Points		X
D. Intermediate pumps or tanks		X
3. Pump Suction conditions		
A. Suction direct from suction well	X	
B. Suction line in which the critical period ($2L/a$) is 1 second or less	X	
C. Suction line in which the critical period ($2L/a$) is greater than 1 second		X

If the pumping system to be analyzed contains any items listed under category "B", it is recommended that the system be referred to experts for analysis.

If the pumping system to be analyzed contains only items listed under category "A", proceed to Table 7.

TABLE 7

CHECK LIST FOR FORCE MAINS OF CATEGORY "A" ITEM ONLY

YES NO

	YES	NO
1. Is "Critical Period" greater than 1.5 seconds?		
2. Is the maximum flow velocity in the force main greater than 4.0 ft/sec?		
3. Will any check valve in the force main close in less than the "critical period" (2L/a)?		
4. Will the pump or motor be damaged if allowed to run backwards, up to full speed?		
5. Is the factor of safety for the force main less than 3.5 under normal operating conditions?		
6. Are there any automatic quick closing valves in the force main set to open/close in less than 5 seconds?		
7. Are there any automatic valves within the pumping system that become inoperative due to loss of pumping system pressure?		
8. Will the pump(s) be tripped off prior to full closure of the discharge valve?		
9. Will the pump(s) be started with the discharge valve open?		

If the answer to any one of the above questions 1 thru 6 is yes, there is reason for concern regarding surge pressures. If two or more of the above questions 1 thru 9 are answered yes, the situation is likely to be serious and the degree of severity will be in proportion to the number of yes answers.

2.15 Examples of Surge Pressure in a Force Main

The following are examples to illustrate the use of Tables 6 and 7 (Section 2.14.8) as well as the various equations presented previously, which are intended to assist in determining the probable effects of surge pressures.

2.15.1 EXAMPLE NO. 1

2.15.1.1 Design Data:

1. Pumps: Three (3) identical units (1 standby),
Rated Flow (each) = 5000 gpm (7.2 mgd).
Station Design Capacity = 10,000 gpm (14.4 mgd).
Assumed Pump Rundown Time Under Full Head = 1.5 Seconds.
Rated Discharge Head = 78 Feet.
2. Force Main: 26-inch Diameter Steel Pipe, Length = 8000 Feet.
3. Valves: 24-inch C.I. Plug Valves (suction side).
18-inch C.I. Plug Valves (discharge side).
18-inch Swing Check Valves (discharge side).
4. Pump Suction: Suction directly from wet well through 24-inch diameter suction pipe ($2L/a = 2 \times 15/3500 = < 1$ second)

2.15.1.2 Data for Surge Pressure Analysis:

1. Steady State Conditions:
 - a. Flow = 14.4 mgd = 22.3 cfs
 - b. Velocity = 6.24 ft/sec
 - c. Total Head = 78 feet
 - d. Static Head = 5 feet
2. Critical Period:
 - a. Wave Velocity, $a = 3500$ ft/sec (assumed)
 - b. $2L/a = 2 \times 8000/3500 = 4.5$ sec
3. Force Main Profile:
 - a. No Intermediate High Points
 - b. Relative Slope = $L/\Delta H = 8000/80 = 100 > 20$
4. Cause of initial surge pressure = power failure.

5. Sudden or gradual velocity change = sudden, since the assumed pump run down time of 1.5 seconds is less than the critical period of 4.5 seconds.

6. Maximum Surge Pressure Anticipated:

$$\begin{aligned}h_w = av \div g &= 3500 \text{ ft/sec} \times 6.24 \text{ ft/sec} \div 32.2 \text{ ft/sec}^2 \\ &= 21,840 \text{ ft}^2/\text{sec}^2 \div 32.2 \text{ ft/sec}^2 \\ &= 678.3 \text{ feet (294 psi)}\end{aligned}$$

2.15.1.3 Classification of Force Main:

Using Table 6, all applicable items fall under the "A" category, therefore, proceed to Table 7.

2.15.1.4 Force Main Check List Items:

Items receiving "yes" answers:

No. 1. Critical period greater than 1.5 seconds.

No. 2. Flow velocity greater than 4.0 ft/seconds.

Items receiving "questionable" answers:

No. 3. Closure of check valve less than the critical period (4.5 seconds)

No. 4. Will pump and/or motor be damaged by reverse rotation.

This example indicates that there is a potentially serious surge pressure condition that could occur due to the possible sudden closure of the check valve(s). Additionally, it indicates that there may be a concern regarding the potential damage that could be caused by reverse rotation of the pump and/or motor along with a possible need to review this condition with the manufacturer.

2.15.2 EXAMPLE NO. 2

2.15.2.1 Design Data: Same as for Example No. 1

2.15.2.2 Data For Surge Pressure Analysis:

1. Steady State Conditions:

a. Flow $Q_1 = 14.4 \text{ mgd} = 22.3 \text{ cfs}$
 $Q_2 = 7.2 \text{ mgd} = 11.1 \text{ cfs}$

b. Velocity $v_1 = 6.24 \text{ ft/sec}$
 $v_2 = 3.12 \text{ ft/sec}$

c. Total Head = 78 feet

d. Static Head = 5 feet

2. Critical Period: Same as for Example No. 1

3. Force Main Profile: Same as for Example No. 1

4. Cause of initial surge pressure = Loss of power to one of the two pumps running.

5. Sudden or gradual velocity change = sudden, since the assumed pump rundown time of 1.5 seconds is less than the critical period of 4.5 seconds.

6. Maximum Surge Pressure Anticipated:

$$h_w = a/g (v_1 - v_2) = \frac{3500 \text{ ft/sec}}{32.2 \text{ ft/sec}^2} (6.24 \text{ ft/sec} - 3.12 \text{ ft/sec})$$

$$= 108.7 \text{ 1/sec} (3.12 \text{ ft/sec})$$

$$= 339 \text{ feet (147 psi)}$$

2.15.2.3 Classification of Force Main:

Using Table 6, all applicable items fall under the "A" category, therefore, proceed to Table 7.

2.15.2.4 Force Main Check List Items:

Items receiving "yes" answers:

No. 1. Critical period greater than 1.5 seconds.

No. 2. Flow velocity greater than 4.0 ft/sec initially.

Items receiving "questionable" answers:

No. 3. Closure of check valve in less than the critical period of 4.5 seconds.

No. 4. Will pump or motor be damaged by reverse rotation.

2.15.2.5 This example indicates that there is a potentially serious surge pressure condition that could occur due to the possible sudden closure of the check valve(s). Additionally it indicates that the severity of the surge pressure will be less than if both pumps were suddenly shut down. It also indicates that there may be a concern regarding the potential damage that could be caused by reverse rotation of the pump and/or motor along with a possible need to review this condition with the manufacturer.

2.15.3 EXAMPLE NO. 3

2.15.3.1 Design Data:

1. Pumps: Two (2) identical units (1 standby)
Rated Flow (each) = 3000 gpm (4.3 mgd)
Station Design Capacity = 3000 gpm (4.3 mgd)
Assumed Pump Rundown Time under full head = 1.5 seconds.
Rated Discharge Head = 55 feet
2. Force Main: 26-inch diameter steel pipe Length = 6500 feet
3. Valves: 16-inch C.I. plug valves, manually operated on suction and discharge of pumps.
4. Pump Suction: Suction directly from wet well through 16-inch diameter suction pipe $(2L/a) = (2 \times 15/3500) = <1$ second.

2.15.3.2 Data For Surge Pressure Analysis:

1. Steady State Conditions:
 - a. Flow = 4.3 mgd = 6.65 cfs
 - b. Velocity = 1.87 ft/sec
 - c. Total Head = 55 feet
 - d. Static Head = 5 feet
2. Critical Period:
 - a. Wave Velocity, $a = 3500$ ft/sec (assumed)
 - b. $2L/a = 2 \times 6500/3500 = 3.7$ sec
3. Force Main Profile:
 - a. No intermediate high points.
 - b. Relative slope = $L/\Delta H = 6500/55 = 118 > 20$
4. Cause of initial surge pressure = Power failure.
5. Sudden or gradual velocity change = Sudden, since the assumed pump

rundown time of 1.5 seconds is less than the critical period of 3.7 seconds.

6. Maximum Surge Pressure Anticipated:

$$\begin{aligned}h_w &= av \div g = 3500 \text{ ft/sec} \times 1.87 \text{ ft/sec} \div 32.2 \text{ ft/sec}^2 \\ &= 6545 \text{ ft}^2/\text{sec}^2 \div 32.2 \text{ ft/sec}^2 \\ &= 203.3 \text{ feet (88 psi)}\end{aligned}$$

2.15.3.3 Classification of Force Main:

Using Table 6, all applicable items fall under the "A" category, therefore proceed to Table 7.

2.15.3.4 Force Main Check List Items:

Items receiving "yes" answers: No. 1 Critical period greater than 1.5 seconds.

Items receiving "questionable" answers: No. 4 Will pump and/or motor be damaged by reverse rotation.

2.15.3.5 This example indicates that there is a potentially minor surge pressure condition that could occur due to the shut down of the pump on a loss of power. It also indicates that there may be a concern regarding the potential damage that could be caused by reverse rotation of the pump and/or motor along with a possible need to review this condition with the manufacturer.

2.16 Surge Relief Valves

Surge relief valves are typically installed at pump stations to protect the pumps, piping, valves and other equipment from potential damage from surge pressures. Surge relief valves should be sized to release the excess surge flows through the valve either on the basis of system flow or so that the inlet pressure measured at the relief valve will be lower than the lowest pressure rating of the pumping equipment.

All manufacturers of surge relief valves have a value size selection chart in their catalog for the purpose of selecting the proper sized valve for the force main system, or portion thereof, to be protected. Figure 5 is an example of a valve size selection chart, which is reproduced from the GA Industries, Inc. Catalog No. GA-2000.

Surge relief valves are to be located downstream of the pump control valve/check valve or on the main discharge header as close to the pump(s) as practical. Surge relief valves typically discharge back into the wet well.

Consideration should be given to providing two or smaller sized valves having a total combined relieving capacity equal to or greater than a single larger sized

valve, especially when there is more than one pump discharging into a common header. A surge relief valve may be utilized on each pump discharge line or several valves may be provided on the common discharge header.

When several valves are provided, it is advisable that each valve's pressure setting be slightly higher than the adjacent valve allowing the valves to open in sequence instead of all at once. It should be noted that all surge relief valves are field adjustable and their relief pressure setting range is determined when the valves are ordered from the manufacturer.

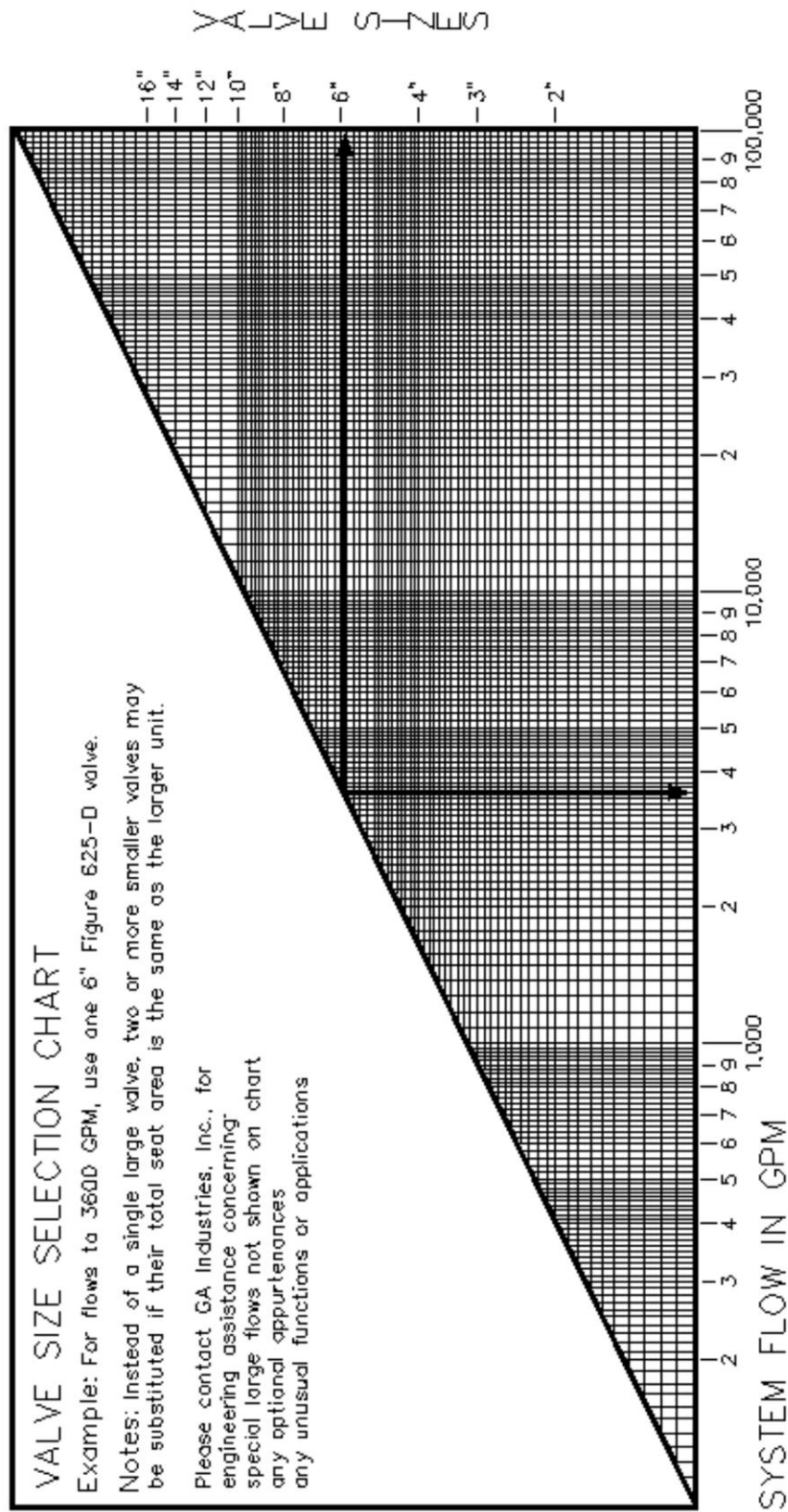


Figure 5
 Example of Surge Relief Valve Size Selection Chart

2.17 Pipeline Design

2.17.1 Refer to the latest edition of the City of Houston "Design Guidelines for Lift Station and Force Mains" for additional design criteria.

2.17.2 Pipeline velocity higher than 6 fps should be checked for possible high and low negative surge pressures during a power failure when all running pumps stop suddenly.

2.17.3 The length of the pipeline should be kept as short as practical to decrease the detention time and odor generation.

2.17.4 The vertical alignment of pipeline should avoid a steep slope of pipe near the pump station followed by a long stretch of flat grade. This type of alignment is often the cause of column separation. See Figure 6. A rising pipe followed by a falling one will require an air vent to be installed at the summit.

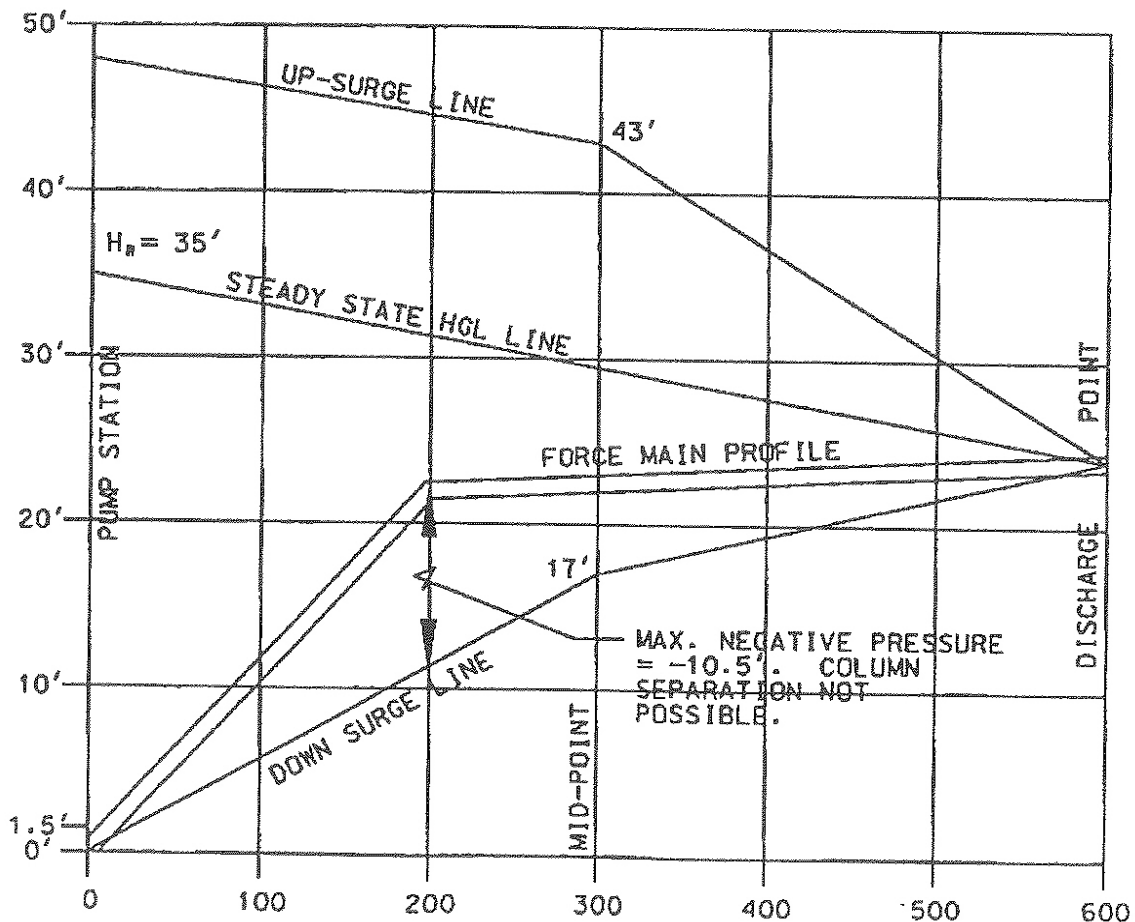


Figure 6
Example of Column Separation Determination

2.17.5 Pipeline passing through peaks and valleys require vents at the high point and drains in the low point. Such pipe profiles should be checked very carefully for air

entrapment and air release. Either one could cause high surge pressure due to improper selection of air valve sizing. Also, the static head of a pipeline having ups and downs with entrained air pockets should be carefully checked. Under certain conditions the static head of each water column should be added cumulatively, even though they appeared to be canceling each other. See Figure 7.

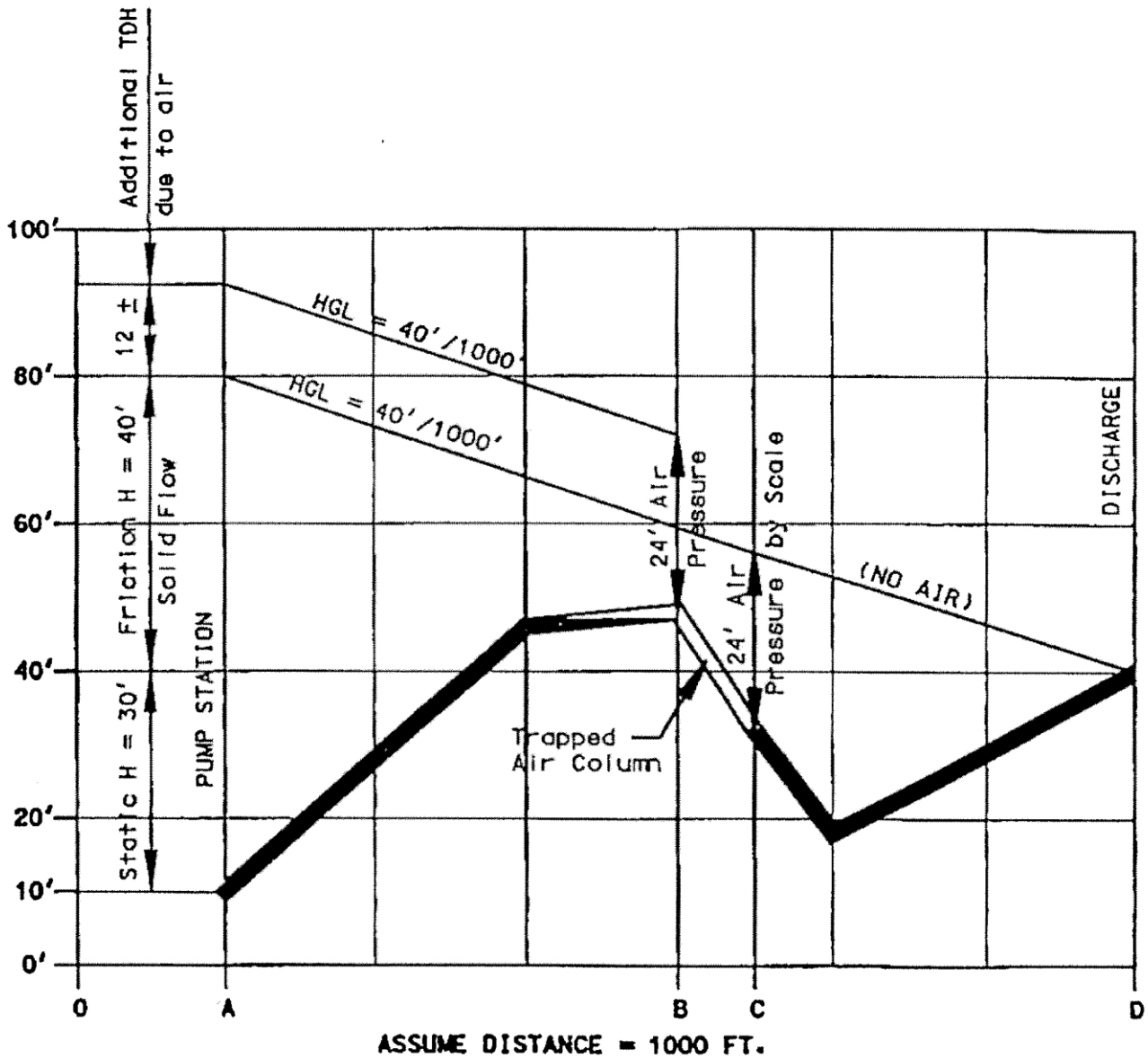


Figure 7
Effect of Air Entrapment on Pump TDH

2.18 Check Valves

- 2.18.1 For pump system head of 30 psi or less, the maximum velocity through a non-spring loaded or counter-weighted check valve should not exceed 3 fps. It may be increased to 5 fps for check valves, which are spring loaded or counter weighted to prevent valve slamming. For pump system head higher than 30 psi cushioned swing check valves should be used. However, cushioned swing check valves do not eliminate pressure surges when the valve closes suddenly. It only reduces the slamming noise.
- 2.18.2 One valve manufacturer recommends that the counter-weight arm should be installed in a horizontal position when fully closed if the valve will open to an upward angle of 45 degree at the maximum operating capacity. The arm may be installed at a 30 degree downward angle if the valve will open to an upward angle of 60 degrees or more at the maximum operating capacity. This is important in order to ensure that valve will be fully closed before the pressure wave returns to the valve location.
- 2.18.3 When pumps are stopped suddenly, as during a power failure, the pressure inside the force main will rise when the return pressure wave reaches the closed check valve. The amount of pressure rise may be any where between 40 to 70 percent above the normal pump operating head. Power operated check valves are sometimes used to control the pressure rise at the pump to a minimum.
- 2.18.4 The following standards should be used unless they are verified to the contrary by computer surge analysis.
- a) The force main pipe should be specified to be capable of sustaining a negative pressure of -8 to -10 psig. The maximum surge allowance of the pipe should be about 70% of the maximum operating pressure when swing check valves are used.
 - b) In a high-pressure pumping system where the amount of pressure rise is severely limited, power-operated check valves should be considered. By proper selection of the valve closing time, pump back-spinning can be prevented.
 - c) A system where zero pressure rise is desired can be achieved by allowing sewage to return to the wet well while the check valve is closing slowly. Under such condition the maximum reverse speed of the pump must be estimated and clearly stated in the project specifications.
- 2.19 Shut-off Valves: Plug valves or resilient-seat, solid-wedge gate valves should be used for shut-off service in a sewage force main application when the liquid being pumped contains gritty material. Outside Yoke and Screw (OY&S) rising stem gate valves are preferred by some operators to Non-Rising Stem (NRS) gate valves because their gate positions can be readily identified. Because of the conventional type of packing that is used in OY&S gate stem seals they may require occasional adjustment.

2.20 Blow-off Valves

Low points in a sewage force main should be provided with a blow-off valve especially when the sewage contains grit and other inorganic solids and the pipe slopes of the falling and rising legs are steep. The blow-off liquid may be drained to a nearby gravity sewer or be hauled away in a tank truck. If pumps can be operated once each day to provide the required flushing velocity un-interruptedly for such a duration that the volume inside the falling and rising legs can be replaced with the fresh sewage the blow-off valve may be omitted.

2.21 Air and Vacuum Valves

Sewage pump station design utilizing submersible pumps will usually have the check valves installed closer to the ground surface for easy maintenance. Such arrangement frequently requires an air and vacuum valve to be installed on the pump side of the check valve to prevent vacuum pressure being developed inside the vertical riser pipe when the pump stops; and to allow the air to be completely vented to the atmosphere with little or none being passed into the force main through the check valve. When the difference in elevation between the low wet well water level and the top of the discharge pipe, at the check valve, is less than 25 feet, air and vacuum valves may be omitted. On longer riser pipes air and vacuum valves must be installed and the following procedures may be followed in computing the valve size required:

- Step 1. Determine the vertical distance in feet between the check valve and the minimum water level. If it is less than 10 feet, no vacuum relief valve is required.
- Step 2. Determine the maximum pump operating capacity in cfs. Convert pump capacity in gpm to cfs by dividing by 448. This should be equal to the required valve venting capacity.
- Step 3. Select the required valve size from an Air Vacuum Valve Discharge Capacity Chart similar to the one shown in Figure No. 8. Valve manufactures normally recommended 2.0 psig as the design outflow pressure; this could be reduced to 1.0 psig when frictional head loss through shut-off valve and vent pipe is included.

Example: Determine the size of an air and vacuum valve required to vent the air volume inside 30 feet of 16-inch riser pipe between the check valve and the minimum pumping level in the wet well, assume the maximum pump discharge capacity is 5.0 mgd (7.75 cfs).

Vertical Distance of riser pipe = 30.0 feet

Actual pump capacity, or valve vent capacity = 7.75 cfs

Valve venting capacity from Manufacturer's Data:

1" Valve = 2.0 cfs
2" Valve = 5.0 cfs
3" Valve = 10.0 cfs
4" Valve = 13.0 cfs
6" Valve = 32.0 cfs

Valve size Selected = 3.0 inches.

Since the vertical distance is greater than 10 feet, a vacuum and air release combination valve should be specified.

Sewage type air vacuum valves should be used in sewage pump station applications. These valves are furnished with flushing-out hose connections.

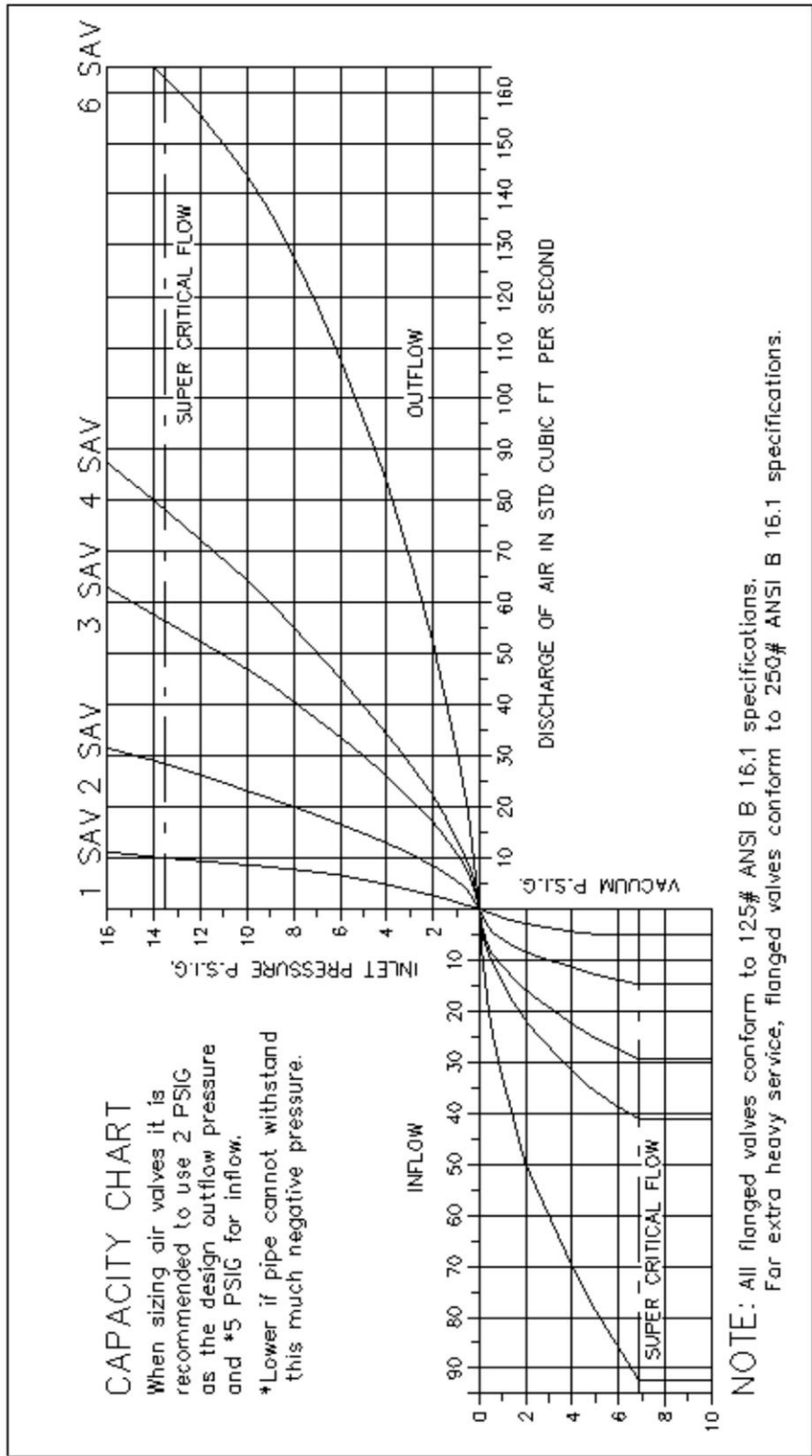


Figure 8
 Air Vacuum Valve Capacity Chart

2.22 Provisions for Lift Station By-Pass

The lift station design should include provision to install temporary pumps and the connection of these pump to the lift station force main. Typically this is accomplished by placing a “Tee” on the force main on the lift station site and installing a valve on the branch of the “Tee”. It is preferred to install a by-pass “Tee” and valve in a manhole on the lift station site.

2.23 Site Requirements

2.23.1 Lift station site evaluation needs to include assessment of the following:

2.23.1.1 Visual impact on the neighborhood. Sufficient setback from the property line to the fence line should be provided to accommodate the required landscape buffer. In all cases, setback from property lines as governed by COH ordinances should be followed.

2.23.1.2 Access to the site for lifting equipment to provide sufficient pavement area and clearance to accommodate full movement and operation as may be required to lift pumps selected for the specific site.

2.23.1.3 Sufficient pavement area to allow turnaround of a 1-1/2 ton truck within the fenced area. Provide entrance gate with sufficient setback to allow entrance of 1-1/2 ton truck without blocking the main roadway. The requirement may be relaxed for very large sites.

2.23.1.4 Generally, the entire site within the fenced area is paved. Locate the fence one foot inside the paved area. Where adjacent to existing structures, locate the fence further in the site to provide a minimum 6-foot clearance for grounds maintenance.

2.23.1.5 Consideration for future chemical feed and storage facilities; including access, sufficient pavement area and clearance to accommodate full movement and operation of a chemical delivery truck should be part of the odor and corrosion control analysis.

2.23.1.6 Clearance for construction and maintenance.

2.23.1.7 Site Security

2.23.1.8 Odor potential and impact to the neighborhood

2.23.1.9 Structure depth and its potential impact on adjacent areas.

2.23.2 Site Size

2.23.2.1 At least 20 feet clearance between all sides of the lift station facilities and fence line should be provided where feasible.

2.23.2.2 Site size is function of facility capacity. The Table 8 should be considered the minimum guideline for site size of various diameters of lift station wet wells.

Table 8

Lift Station Configuration Pump Ranges, Capacity Ranges, Discharge Piping, Wet Well Size and Site Size

Number of Pumps	Individual Pump Capacity – GPM		Lift Station Firm Design Capacity – GPM		Pump Discharge Piping - Inches		Minimum Wet Well Diameter - Feet	Minimum Site Size
	From	To	From	To	From	To		
2	0	199	0	199	4	4	6' – 0"	55' x 55'
2	200	499	200	499	4	8	8' – 0"	55' x 55'
2	500	999	500	999	8	10	10' – 0"	70' x 70'
3	250	500	500	999	6	10	10' – 0"	70' x 70'
3	500	999	1000	1998	8	10	12' – 0"	75' x 75'
3	1000	1399	2000	2798	10	12	14' – 0"	75' x 75'
3	1400	1999	2800	3998	12	16	16.5' – 0"	75' x 75'
3	2000	3499	4000	7198	16	24	21' – 0"	85' x 85'
4	800	3499	2400	10,497	10	20	21' – 0"	85' x 85'
5	2500	3999	7500	15,996	18	20	25' – 0"	85' x 85'
6	3000	5299	15,000	21,196	18	20	28' – 0"	90' x 90'

Note: This table has not been coordinated with the City of Houston Design Guideline Drawings for Submersible Pump Lift Stations dated 1996. These drawings are currently being revised and will be issued at a later date.

2.23.3 The site of the lift station should generally be located on a full parcel. Lift stations should not be located in:

2.23.3.1 Street right-of-way

2.23.3.2 Easements

2.23.3.3 Areas where future maintenance access, security, or odor mitigation could become difficult.

2.23.3.4 Topography where the top or main floor of the station cannot practically be physically located above the 500-year flood elevation, and/or where the site cannot be made accessible during the 25-year flood event.

2.23.4 To the extent possible, lift station site layout should be oriented according to the prevailing wind direction so as to minimize potential for hydrogen sulfide odor problems with adjacent areas as well as minimize potential for gases to enter electrical panels or control building intake grills.

2.23.5 Access

2.23.5.1 Locate site security fence and entrance gate back from the street turnout for a 1-1/2 ton service truck so that the truck will be off the main roadway when the operator stops to unlock the access gate.

2.23.5.2 Where permanent on-site chemical storage tanks are used, provide sufficient tanker truck access. Provide roadway turnout of appropriate geometry such that chemical delivery truck does not sit on the main roadway when making delivery. Truck turnout inside radius should not be less than 50 feet.

2.23.5.3 Access roadway width should not be less than 16 feet and turnout radius should not be less than 30 feet inside (50 feet preferred) or such greater dimension as necessary to prevent truck or crane wheel overrun from the pavement.

2.23.5.4 Crane access and setting location to be used for lifting out submersible pumps or other equipment should be specifically addressed in the facility layout; for example site sizing should consider crane swing area, orientation hatches and lifting capacity.

2.23.5.5 Provide low maintenance type paving into the site and around the inside of the site meeting H-20 loading requirements.

2.23.5.5.1 Provide parking spaces only inside the secure site area.

2.23.5.5.2 Low maintenance paving is defined as reinforced concrete, asphaltic concrete or pervious concrete pavement as required, of sufficient design and thickness for loads to be encountered. At a minimum, pavement thickness should be 7-inches. For projects in the ETJ areas outside of the City an all weather surface may be acceptable.

2.23.5.5.3 Turf paver system should only be used when required by neighborhood for aesthetics.

2.23.5.5.4 Provide reinforced concrete pavement and/or pervious concrete pavement as required, at uniform elevation, adjacent to and around the lift station. Width should be as necessary for proper mobility of the appropriate vehicle and not less than 12 feet.

2.23.5.5.5 In order to minimize grounds maintenance and such items as grass and weeds cutting, it is preferred that the reinforced concrete and/or pervious concrete pavement extend totally within the secured paved area. Extend the concrete edge one foot beyond the fence line to provide a "mow" strip and minimize maintenance.

2.23.6 Security

2.23.6.1 The security system should meet all requirements of the Texas Commission on Environment Quality (TCEQ), as amended, but as a minimum the following COH requirements apply.

- 2.23.6.2 Site security should be provide by a full-perimeter 6-foot high fence topped with barbed wire. Site access will be through one 16-foot wide, double leaf, inward-opening swing gate secured with a chain and padlock. The fence should also include a pedestrian gate, easily accessed from the entrance drive with the same chain and padlock system described above.
- 2.23.6.3 Other intrusion security measures will be considered on a case-by-case basis if special conditions or requirements dictate.
- 2.23.6.4 The preferred fence is green PVC-coated, minimum No. 9 gauge galvanized woven wire, 6-foot high fabric, 2-inch open-diamond mesh pattern, cyclone-type fence topped with barbed wire. Such a security fence provides visibility into the protected station area so the presence of unauthorized persons can be detected before entry.
- 2.23.6.5 If determined necessary that fencing material should match those used in the neighborhood, hanging such matching material on the exterior of the chain link fence for decoration should be considered, as opposed to using a alternative fence system.
- 2.23.6.6 Where necessary to avoid subsidence of the fence system, consider the use of a concrete grade beam in which the steel line posts are set. Use minimum 24-inch deep beam with 6-foot long concrete support piles spaced not greater than 16 feet on center.
- 2.23.7 Landscaping
 - 2.23.7.1 Provide landscaping to meet the requirements of the latest COH ordinance. As a minimum provide landscaping that meets the requirements described below.
 - 2.23.7.2 Station design needs to be safe, simple and aesthetically blend into the surrounding landscape. Prefer the use of drought resistant – native plants.
 - 2.23.7.3 In order to promote a good neighborhood policy, minimize the amount of mud runoff, minimize interim maintenance and unsightliness, and promote vegetation growth in the construction zone, all disturbed areas and soil landscaping areas should be grass-sodded instead of hydro-mulched.
 - 2.23.7.4 Landscape only outside of the security fence.
 - 2.23.7.5 Consideration should be given to enlisting the assistance of the local neighborhood association in being responsible for the exterior landscaping maintenance around the station.
 - 2.23.7.6 Include an automatic irrigation system in the design, if required.
- 2.24 Corrosion Control

- 2.24.1 Design should include consideration for corrosion protection for interior concrete surface of wet wells, structural steel and fasteners, HVAC systems, electrical, mechanical and other components that could be affected by the corrosive environment.
- 2.24.2 Concrete Protection
 - 2.24.2.1 Provide corrosion protection over the entire concrete surface of the wet well from a plane one foot below the design low liquid level upward to and including the overhead ceiling/roof.
 - 2.24.2.2 PVC sheet material applied to formwork and embedded in new cast-in-place concrete structure is the preferred method of protection. Liners should be one of the following:
 - Ameron T-Lock and Amer-Plate plain sheet
 - Poly-Tee PVC ribbed liners
 - 2.24.2.3 Lift station rehabilitation projects should include lining the wet well as described in 2.24.2.1 with Lina-Bond liner system .
- 2.24.3 Pumps, Piping and Valve Protection
 - 2.24.3.1 Ferrous surfaces of pumps, piping and valves should be coated as described in COH standard specification section 09901, Protective Coatings.
- 2.24.4 Miscellaneous Metals and Hardware
 - 2.24.4.1 All anchor bolts and other fasteners into concrete should be Type 316 stainless steel.
 - 2.24.4.2 Exterior doors should be fabricated with corrosion resistant material.
- 2.25 Odor Control
 - 2.25.1 Odor control at lift stations is not mandatory but should be considered and addressed in the Preliminary Engineering Report. In general odor control for City of Houston lift stations will only be required if requested by the Project Manager. Odor control for non-City of Houston lift stations will be at the discretion of the Design Engineer. The following methods and criteria should be considered as a minimum guideline.
 - 2.25.1.1 Chemical feed systems should be considered at lift stations that have discharge force mains longer than 2,000 feet.
 - 2.25.1.2 The standard treatment for odor control is ferrous sulfate fed directly into the upstream manhole, pump station wet well or force main, in that order of preference.
 - 2.25.1.3 Use of nitrate containing products for odor control may also be considered.

2.25.1.4 The use of activated carbon canister devices on the wet well vent pipe may be applicable.

2.25.1.5 Biofilter systems may be considered for lift station odor control.

2.25.2 Air Treatment Systems

2.25.2.1 Duct Work should be designed based on the following criteria.

2.25.2.1.1 Material of Construction

2.25.2.1.1.1 Below Grade – Sch 40 or SDR 35 PVC, or DR 32.5 HDPE

2.25.2.1.1.2 Above Grade – FRP coated for UV protection or 304 stainless Steel

2.25.2.1.2 Air Velocity – 1500 to 2500 ft/min

2.25.2.1.3 Ventilation Rate – the air changes per hour should be based on NFPA 820-Fire Protection in Wastewater Treatment Plant (current edition) issued by the National Fire Protection Association but should not be less than 15 to 25 changes per hour.

2.25.2.2 Exhaust Fan

2.25.2.2.1 Fan should be corrosion resistant with slide mount motor to allow sheave replacement.

2.25.2.2.2 Fans located outside should be noise suppressed.

2.25.2.2.3 Flexible connectors should be used for inlet and outlet connections.

2.25.2.2.4 Provide fan volute with a drain to remove liquids

2.25.2.3 Air Treatment Unit

2.25.2.3.1 Biofilter – the criteria shown in table 9 is for guidance only. These criteria may be modified with appropriate engineering justification and/or manufacturer's recommendations. Note, the follow design criteria is applicable for hydrogen sulfide concentration of less than 50 ppm. Concentrations over 50 ppm require lower loading rates and special consideration.

**Table 9
Biofilter Design Criteria**

Media Type	Inorganic
Air Plenum Depth (inches)	12-18
Media Depth (feet)	4-6
Loading Rate (cfm/ft ²)	12-18
Empty Bed Contact Time (EBCT) (seconds)	20-30
Maximum Inlet Hydrogen Sulfide Concentration (ppm)	50
Maximum Pressure Drop through the Media (inches w.c./ft media depth)	0.25-0.33
Initial Phase pH Range	7-8.5
Media Moisture Content (% by weight)	40-60
Media Porosity (%)	40-50
Water Usage (gallons/100,000 ft ³ of air)	10
Maximum Air Temperature (°F)	105
Anticipated Media Lift (years)	10-15

2.25.2.3.2 Activated Carbon – Activated carbon naturally adsorbs volatile organics but must be specially treated to adsorb hydrogen sulfide.

2.25.2.3.2.1 Typical beds velocities are between 50 and 75 feet per second.

2.25.2.3.2.2 The COH will not regenerate activated carbon. The design must include provisions for carbon replacement.

2.25.2.3.2.3 Activated carbon units are generally considered applicable for small lift stations and remote locations.

2.25.3 Chemical Feed Systems – Chemical feed system consists of chemical storage tanks, chemical metering pump, pump calibration equipment, and associated piping and controls.

2.25.3.1 Provide chemical resistant motor drive diaphragm metering pumps with spare parts, calibration cylinder and corrosion resistant pump stand. The metering pumps should have a feed rate of 3 GPH to 30 GPH and be capable of operating in manual or automatic modes.

2.25.3.2 Provide a panel mounted metering system with control panel, stop valve, relief valve, back pressure valve and pressure gage.

2.25.3.3 House the metering pumps in a lockable FRP building equipped with lights and a GFI outlet.

2.25.3.4 Provide an eye wash station for the chemical feed system.

2.25.3.5 Design Criteria for chemical feed systems is given in Table 10.

Table 10 Chemical Feed System Design Criteria		
Parameter	Ferrous Sulfate	Nitrate
Method of Chemical Delivery	Bulk Liquid	Bulk Liquid
Design Dosage	4.5 lbs FeSO ₄ /lb DS	10 lbs NO ₃ /lb DS
Maximum Allow DS at Discharge (mg/L)	<1	0.3 to 0.5
Storage Tank Capacity (days)	4-7	4-7
Storage Tank Capacity (gallons)	3200-6500	3200-6500
Storage Tank Material	HDPE	HDPE
Secondary Containment	Required	Required
Number of Chemical Metering Pumps	2	2
Chemical Feed Point	Wet Well, above high water level, or first upstream manhole	Wet Well, above high water level, or first upstream manhole

SECTION 3
STRUCTURAL DESIGN CRITERIA

SECTION 3

STRUCTURAL DESIGN CRITERIA

3.1 Specification Codes

3.1.1 The following codes, specifications, recommendations, allowable stresses, and loadings will be used as a minimum in designing the project structures, latest editions:

1. Uniform Building Code UBC with City of Houston Amendments.
2. Building Code Requirements for Reinforced Concrete (ACI 318).
3. Details and Detailing of Concrete Reinforcement (ACI 315).
4. Manual of Engineering and Placing Drawings for Reinforced Concrete Structures (ACI 315R).
5. Environmental Engineering Concrete Structures (ACI 350R).
6. AISC Specification for Structural Steel Buildings Allowable Stress Design and Plastic Design, and Manual of Steel Construction, Allowable Stress Design.
7. AASHTO Standard Specifications for Highway Bridges.
8. Geotechnical Report.

3.2 Loads

3.2.1 Pump Station and Valve Vault Structures Below Grade

1. Hydrostatic liquid pressure due to maximum internal operating liquid level with no balancing external lateral pressure 63 pcf
2. Poorly draining sand or sand and gravel, lateral pressure 80pcf (min) or Per Soil Rpt.
3. Compacted silty clay, lateral pressure 100 pcf (min) or or Per Soil Rpt. Per Soil Rpt.
4. Lateral load due to surcharge loading of the construction crane and H-20 truck shall be added to load (b) and (c).
5. All Structures shall be designed to resist buoyancy to the finished top slab, see Section 3.3 for buoyancy calculation requirements.
6. Top Slab at or above Grade:
DL: Weight of Concrete Slab
SDL: Backfill or other Superimposed Dead Loads
LL: 300 psf or equipment weight plus 50 psf.

7. Fiber Reinforced plastic cover, platform, and walkways at or below grade.
LL: 150 psf

3.2.2 Buildings and Miscellaneous Structures

Loadings for design of buildings to be obtained from appropriate codes. However, certain minimum loads shall be used as follows:

Minimum Uniform Live Loads:

Grating	150 psf
Stairs and catwalks	150 psf
Electrical control rooms	250 psf

(Estimate support area and equipment weights and assume loads applied anywhere in area in question)

Wind: As per UBC for basic wind speed = 90 mph. Exposure C and Importance factor = 1.15

3.3 Buoyancy

The below grade wet wells and valve vaults will be subject to buoyant forces as defined in Section 3.2. Since a bentonite slurry may be used in the caisson excavation, the safety factor listed for soil friction reflects its presence. Verify that the required factors given by the geotechnical consultant are consistent with this. The structure weight shall only include the walls and slabs. The weight of fillets, baffle walls, pads, and equipment shall not be included as these could be changed in the future or may not be in place during construction.

3.4 Design Stresses

3.4.1 Concrete and Reinforcing Steel

1. Liquid Containing Structures:

Use Strength Design Method of ACI 318, Building Code Requirements for Reinforced Concrete, with durability factor per ACI 350 R-89 Environmental Engineering Concrete Structures, and base crack control on a maximum Z of 115 (The minimum concrete cover for steel reinforcement shall be 4 – inches where in contact with raw sewage.)

Concrete compressive strength at 28 days	$f'_c = 4,000$ psi
Reinforcing steel (A 615, Gr. 60)	$f_y = 60,000$ psi

2. Building and Non-Liquid Containing Structures:

Use Strength Design Method of ACI 318

Concrete compressive strength at 28 days	$f'_c = 4,000$ psi
Reinforcing steel (A 615, Gr. 60)	$f_y = 60,000$ psi

3.4.2 Structural Steel

Follow AISC Specification for the Design, Fabrication and Erection of Structural Steel for Building, latest edition, and use following materials:

1. ASTM A36 unless otherwise specified
2. ASTM A325 H.S. bolts
3. ASTM A307 or A36 bar stock for anchor bolts

3.5 Design Considerations

3.5.1 Wet Well Load Cases:

1. Wet well empty with full lateral exterior load.
2. Wet well filled to the maximum level possible during a power outage, while disregarding exterior soil pressures.

3.5.2 Differential Soil Movement:

Due to the significant difference in foundation elevations between the wet well and the valve slab or vault, there is a potential for differential soil movement resulting from settlement, expansive clays, or movement needed to develop soil friction. This potential movement is most severe where wet wells are constructed by the caisson method. The open cut construction method allows for placing cement-stabilized sand so as to minimize the movement potential. The Guideline Drawings include expansion or rotation joints.

3.5.3 Wet Well Design:

1. Pre – cast manhole risers and reinforced concrete pipes (RCP) are not acceptable for wet well design/construction; except for ASTM C76, Class IV Wall C, RCP, 6 – foot diameter wet wells, less than 30 – feet deep.
2. The circular wet well shall be designed using a recognized shell theory or by using the Portland Cement Association publication, "Circular Concrete Tanks without Prestressing."
3. The Guideline Drawing indicates dowels connecting the wall to the base slab for the caisson construction method. Structural connections between base slab and caisson shall be designed to transfer full base reactions from slab to wall. Full base reactions are:
 - a. For downward load: weight of components supported on the slab plus the weight of liquid at maximum elevation in the wet well;
 - b. For upward load: (1) soil bearing reactions; and (2) hydrostatic uplift pressures, together with any potential soil uplift pressure caused by instability, for empty well. Hydrostatic pressure shall be as defined in Paragraph 3.2.1 Soil Uplift Pressures shall be based on geotechnical analysis.

4. Wall Base Cutting Shoe Details

- a. The minimum depth of the cutting shoe base below the final excavation bottom shall be shown on the drawings. The required depth to maintain bottom stability shall be based on geotechnical analysis. In no case shall the required minimum depth of shoe penetration below the final excavation bottom be less than 1.5-feet.
- b. Under no circumstances shall the excavation depth shown on the drawings require excavation below the top of the inside bevel of the cutting shoe.

3.5.4 Additional Stresses Due to Caisson Construction:

1. Caisson and/or Open Cut types of construction should be designed and shown on the drawings, refer to 1.3.12, 3.5.1, 3.5.2, and 3.5.3.
2. Tilting or out of plumbness may occur during sinking of caisson. Tilting shall be not more than 1-inch per 5-foot depth of caisson. Tilting causes bending stresses in the caisson wall. These additional stresses shall be included in the design of caisson wall.
3. Sudden sinking causes axial tension in caisson wall. When frictional and adhesion forces on upper length of caisson are equal to total weight of caisson, caisson sinking stops. This stoppage causes hang-up forces resulting in axial tension in caisson wall. Minimum hang-up force equal to one half the weight of caisson shall be used in design of longitudinal reinforcement in caisson wall.

3.5.5 Control Building Design

Unless the control building dimensions are changed from what is shown on the guide drawings, only the foundation needs to be designed. Follow the recommendations of the geotechnical report for the type and depth of the foundation.

3.5.6 Valve Vaults

1. Access shall be provided to underground valve vaults. Stairways shall have corrosion resistant, non – slip steps and conform to OSHA regulations.
2. Access over pipes, which extend to greater than 30-inches above the floor, shall be by catwalk as detailed on the guideline drawings. The fiberglass specifications call for the catwalk to be designed by the manufacturer. The drawings need to provide all the dimensions and approximate support leg locations.
3. Use of vault- type or above ground valves and piping is permitted. Valves shall be mounted in a concrete vault, or on an-above ground concrete foundation. Isolation and check valves shall not be located in the wet well.

3.6 Detailing

- 3.6.1 Detailing of the reinforcement shall follow the requirements of ACI 315, ACI 315R, ACI 318, and ACI 350R.
- 3.6.2 All construction joints in water containing and below grade elements shall be provided with a 6-inch PVC water stop. All expansion joints shall be provided with a 9-inch PVC center bulb water stop. Where construction requirement or joint geometry will not allow a 6-inch PVC water stop, a surface applied water stop which forms a positive seal by adhesion or expanding in the presence of water may be used. Notes and/or details shall be added to insure that all joints and joint intersections are continuously sealed.

SECTION 4
MECHANICAL DESIGN CRITERIA

SECTION 4 MECHANICAL DESIGN CRITERIA

4.1 General

- 4.1. This design guide gives criteria and describes procedures for designing of cooling, ventilation and plumbing systems for lift stations. The lift stations include a wet well, and may include either a control building or an outdoor control panel. The valves and discharge piping may be above grade or in a vault below ground depending on specific site requirements.
- 4.1.2 The wet well is a strictly unattended well with submersible pumps. The submersible pumps can be removed from the wet well through the use of a rail guide removal system without the necessity of entering the pit. The Wet Well must not be entered under any circumstances without first providing proper ventilation to remove any explosive or toxic fumes that may be present in it.
- 4.1.3 The valve vault houses isolation and check valves, and could house other devices, which may require periodic checking. Therefore, it is preferred that the valve vault does not have a roof, but the use of solid panels or grating may be used.. Before entering the valve vault, it must be properly ventilated.
- 4.1.4 The control building houses motor control centers, panels, transformers and other equipment required for the lift station operation.
- 4.1.5 Because of solar heat transmission into the control building and heat gains from electrical equipment, the building must be provided with proper cooling to prevent overheating and possible malfunction of electrical devices.
- 4.1.6 The design should comply with applicable criteria by TCEQ codes and NFPA 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

4.2 Wet Well Ventilation

- 4.2.1 Since the wet well is unattended and must not be entered without special provisions, a permanent type ventilation system is not required. Mechanical ventilation must be provided when the wet well is to be entered for any reason. A portable type engine or electrically driven air supply fan should be used. A quantity of outdoor air, equal to at least thirty air changes per hour of the wet well volume must be blown into the well through a flexible pipe. The point of discharge of the air into the well must be where people are present. The air supply fan must be in operation for a minimum of two minutes before anyone enters the well. Entrance hatches must be kept open to allow foul air to escape from the well while outdoor air is being blown in.
- 4.2.2 The ventilation for a wet well should be designed as a passive gravity ventilation system (breather type), where the air volume in the well is either increased or decreased and outdoor air is pulled into the wet well and wet well air is pushed outdoors through the vent pipe, as sewage flows into or is pumped out of the wet well. The passive

ventilation pipe should be sized to allow an inflow of make-up air volume to the wet well, at a rate equal to the maximum liquid pumping rate out of the wet well, with an air velocity through the vent pipe not to exceed 600 fpm. In no case shall the vent pipe be less than six inches in size. Vents shall have stain steel insect screen that is easily replaceable, prevent rain water from entering, and be corrosion resistant.

4.3 Valve Vault Ventilation

4.3.1 The valve vault is normally unattended. However, on occasion it must be entered to service valves and other devices. Access shall be provided using stairways or ladders utilizing corrosion resistant non-slip steps or rungs conforming to OSHA requirements.

4.3.2 Since odors are not normally generated in the vault, continuous ventilation and odor control are not required. There is a possibility, however, that harmful or explosive fumes may enter the vault through cracks in walls or leaking valves. For this reason, the vault must be properly ventilated before anyone enters it. Use the same ventilation requirements as described for wet wells.

4.4 Plumbing

4.4.1 Water from open grating pump access hatches, cracks in walls and floor may leak into the valve vault. Liquids from leaky valves or from valves under repair may also be discharged onto the vault floor. A floor drain to drain the liquids to the adjacent wet well should be provided. The floor drain should have a "P" trap and a floating ball-type backwater valve to prevent fumes and liquids from entering the vault from the wet well. The valve vault floor should be sloped toward the floor drain.

4.4.2 A water supply is needed during repairs, for washing down equipment, valve vault and grade slabs. Water should be provided through a 3/4 inch diameter supply line and non-freeze type hose bib located near the wet well.

4.4.4 All water should be metered and supplied through a reduced pressure type backflow preventer for protection of the city water mains from possible contamination due to cross-connections.

4.4.5 The above grade water supply system pipe, fitting, valves, and water meter should be insulated and protected against freezing. The complete backflow preventer assembly should be provided with a vandal proof enclosure and equipped with access provisions for servicing and checking of the equipment.

4.5 Control Building Cooling

4.5.1 Control Buildings house motor control centers, electrical panel's, transformers, and other equipment for operating pumps located in Wet Wells.

4.5.2 The temperature in the buildings will be affected by solar heat gain, by thermal conduction and convection, and by heat radiated from electrical equipment. If the excess heat is not removed either with ventilation air or by mechanical cooling, the

temperature in the building will rise to a point where electrical devices will malfunction and disrupt operation of the pumping station.

- 4.5.3 Where clean outdoor air at suitable temperatures is available, forced ventilation is the least expensive and simplest way of removing heat from a building. Removing heat by forced ventilation should be considered when it is possible to maintain indoor temperatures of not to exceed 105 degrees Fahrenheit at all times. In Houston, however, outdoor air may at times be very saline, and when drawn through a building will cause corrosion and adversely affect delicate electrical instruments and devices. Therefore, controlling building temperature in such atmospheres is best accomplished by providing mechanical cooling units, where minimum or no outdoor air is circulated through the building, thus avoiding possible corrosion of equipment.
- 4.5.4 The mechanical cooling units are also susceptible to corrosion from the saline atmosphere. The useful life of such units will be much shorter in a saline atmosphere than in normal atmospheric conditions. However, the operating life of mechanical units can be extended by specifying that the units will be provided with a protective coating application. Heat transfer capacity of protectively coated coils is not significantly affected (normally a reduction in capacity of less than 10 percent). The coating should cover all parts that come in contact with outdoor air, which includes the casing, heat transfer coils, refrigerant tubing and electrical devices. Mechanical cooling units should be wall mounted package type, heat type, units.
- 4.5.5 When sizing the cooling unit, all instantaneous sources of heat gain must be accounted for. The worst scenario would be with all pumps running and the outdoor temperature 100°F, or higher, and staying within this range for a number of consecutive days. Mechanical cooling units shall be sized to maintain a building indoor temperature of 85 degrees Fahrenheit or less at a 40 percent specific humidity at maximum heat gain.
- 4.5.6 Solar and transmitted heat gain calculations must be in accordance with the ASHRAE Handbook of Fundamentals. The outdoor temperature listed in the ASHRAE Guide must be adjusted for outdoor air temperature encountered in Houston, if such maximum temperature continues within that range for more than 4 hours. Maximum temperatures for the particular area must be obtained locally.
- 4.5.7 Unit Selection should be based on a terminal wall mounted heat pump type mechanical cooling unit having a minimum 13,000 BTUH sensible cooling capacity at 105°F outdoor air temperature at 77°F wet bulb temperature and an air temperature of 85°F dry bulb and 66°F wet bulb entering the cooling coil.
- 4.5.8 The above selected unit is sized for a 4-pump system. The same unit can also be used for stations with fewer pumps and smaller heat gains.
- 4.5.9 The air conditioning unit should be controlled through a room type thermostat set to maintain the room air temperature at approximately 80°F. The unit fan shall run continuously when the unit control switch is in the "on" position.

SECTION 5

ELECTRIC POWER AND INSTRUMENTATION CONTROLS DESIGN CRITERIA

SECTION 5

ELECTRICAL POWER AND INSTRUMENTATION CONTROLS DESIGN CRITERIA

5.1 Basic Data

5.1.1 Prior to assembling a drawing package, the following site specific data must be established and calculations performed. Refer to the current Design Guideline Manual for guidance on fencing requirements, site layout, location of electrical junction boxes, etc.

- Number and size of pumps (gpm & HP/KW)
- Station configuration (Preferred, Secured Site or Exposed Site)
- Location of electrical junction box (above grade or in valve vault)
- Refer to the latest Lift Station Design Guideline. This design document to be used for all lift stations designs within the City of Houston and ETJ area. For projects within the ETJ area, the local communication modem may be replaced by Auto dialer for remote alarm report.
- Fencing requirements
- Electrical power reliability study for alternate power determination
- Full load calculation
- Motor starting analysis and short circuit calculations

5.1.2 Approval of designs for non-PLC lift station electrical and instrumentation controls serving utility districts in the ETJ shall be allowed if one or more of the following conditions are met:

- The District where the lift station is located has a minimum of 15 years remaining under an executed Strategic Partnership Agreement with the City of Houston,
- The project includes a temporary lift station at a wastewater treatment plant,
- The project includes a temporary lift station while the permanent lift station is under rehabilitation, or construction,
- The plans show future expansion of the electrical controls which includes the addition of a PLC,
- The Owner has executed an agreement with the City of Houston stating the area being served by the lift station location will not be annexed.
- The Owner has executed an agreement with the City of Houston with a term not to exceed 15 years, stating that the lift station electrical controls will be upgraded before annexation to the future current design criteria and the Owners shall, subject to the availability of funds from a legally available source, pay for those upgrades without extending the term of the outstanding the indebtedness of the Owner.

If a PLC is not required, the lift station control panel may consist of relay or solid state controls, NEMA compliant switchgear, main circuit breaker, motor starters, over current protection, surge protection, autodialer (or other telemetry,) level control backup system, phase failure monitor, alarms, and other devices deemed necessary by the design engineer. The control panel shall be sized to adequately house the controls and

must be of stainless steel.

5.2 Electrical Drawing Set

5.2.1 Each design package shall contain the following minimum electrical drawings:

- Electrical Symbols Legend, Lighting Fixture Schedule & Abbreviations
- Site plan, including grounding and outdoor lighting
- Conduit Layout Plan
- Conduit Layout Sections
- Electrical Design Details
- Control Building Plan (for sites with control buildings)
- Control Cabinet Layout
- Process and Instrumentation Diagram
- Control System Wiring Diagrams
- MCC & PLC Power Schematic Wiring
- Single Line Diagram
- Cable and Conduit Schedule
- Device Rating Schedule
- MCC Elevation (for sites with a MCC)

5.2.2 The electrical drawing set is arranged with Guideline plans and details for control system and instrumentation with up to 6 pumps (4 wet weather and 2 dry weather pumps). The contracted design engineer is responsible for adjusting the details in the drawings, the number of pump starters, relays, devices, et cetera, based on the specific configuration. Delete only the devices associated with pumps not provided. DO NOT delete items associated with provided pumps without prior approval of the City of Houston. Some components have been included to provide for ease of future expansion. If there is no dry weather wet weather configuration, design engineer shall consider wet weather configuration as a normal pump configuration up to 4-pump and delete dry weather drawing details. If additional pump is needed, the same format shall be used to add pump to the 4-pump configuration.

5.3 Electrical Symbols, Legend, Lighting Fixture Schedule & Abbreviations Sheet

5.3.1 This sheet defines the symbols and abbreviations utilized in the preparation of the contract drawing package, and schedules the lighting fixtures used. Use this sheet as a guideline for revisions made to the Guideline Drawings

5.3.2 *Include this sheet in each design package. DO NOT delete symbols or abbreviations from this sheet. Add any special items used in the preparation of the final package. Delete any lighting fixtures not used.*

5.4 Site Plan

5.4.1 In addition to the Design Guideline Drawings required, a site specific electrical site plan must be created. After establishment of the basic civil site, the following electrical information must be established and/or added:

- Locate the electrical building or electrical panel in accordance with the COH Design Guidelines.
- Locate the electrical service point.
- Orientate the lift station to coincide with the civil plans.
- Route conduits from electrical service and telephone service locations to the control building/cabinet.
- Locate yard light and route conduit from control building/cabinet.
- Establish site ground field and provide ground connections of service entrance, control building/cabinet, handrails, above grade electrical junction boxes, yard light, piping and all metal parts.

5.4.2 Note: An example of an electrical site plans is included in the Design Guideline Drawing package as referenced material for the Design Engineering. DO NOT include this drawing in the project drawing package without site specific modifications.

5.5 Electrical Plans and Sections

5.5.1 From the Standard Design Guideline Drawings, select the following drawings for the appropriate lift station configuration and size. Review all drawings and details and revise to accommodate specific site and facility requirements. At a minimum, the following review and revisions are required:

- Verify structural dimensions of the valve vault and the wet well and revise the electrical plans accordingly
- Verify the number of active air cell conduits based on the applicable instrument system. Provide adequate air cell and electrical installed spare conduit for anticipated future use.
- Verify drawing number cross references for section callouts
- Verify all sections referenced are included in the document set
- Orient station plans and conduit layout sheets to correspond with the site plan
- Adjust north arrow on each plan sheet
- Add any special or extra features required at this specific site. DO NOT use conduits designated as "future space" for undesignated additions.
- Determine the need for power factor correction capacitors and locate on the drawings. Connect capacitors to the motor starter leads prior to the motor overload relay. Exercise caution to specify capacitors with over-current fuses and indicating lights then locate capacitors within the 25 wire feet distance specified by the N.E.C. Article 240-21.

5.6 Typical Details

5.6.1 The typical electrical details are to be revised and combined as necessary to meet specific site conditions. The listed drawings are based on the latest design guideline updates (September 15, 2009) that includes quick connection (manual transfer switch for portable generator connection) per TCEQ chapter 217. In general, the details apply to the following drawings:

H1e01	X0e56	Z0e01
H2e01	X0e57	Z0e02
H3e01	X0e58	Z0e03
H3e02	X0e59	Z0e04
H3e03	Y0e21	Z0e05
H3e04	Y0e22	Z0e06
H3e05	Y0e23	Z0e10
X0e01	Y0e25	Z0e11
X0e02	Y0e26	Z0e12
X0e03	Y0e30	Z0e13
X0e04	Y0e40	Z0e14
X0e05	Y0e41	Z0e15
X0e06	Y0e50	Z0e20
X0e10	Y0e51	Z0e21
X0e40	Y0e52	Z0e40
X0e41	Y0e53	Z0e41
X0e42	Y0e58	Z0e42
X0e50	Y0e59	Z0e43
X0e51	Y0e60	Z0e44
X0e52	Y0e61	Z0e45
X0e53	Y0e62	Z0e46
X0e54	Y0e63	
X0e55	Z0c01	

5.7 Control Building Plan

Include this sheet in each lift station package with a control building. Revise building dimensions, number of MCC sections, telephone service and conduit plan based on the number and size of pumps. (Control Building dimensions are provided on the Device Rating Schedules). Orient the building plans and add a north arrow to coordinate with the site plan. Revise lightning protection details to coordinate with actual building construction and materials. Relocate alarm light to provide visibility from access road.

5.8 Control Cabinet Layout

Based on the size of the station and the intended location of the control cabinet (indoor or outdoor), select the appropriate control cabinet installation and equipment layout sheet(s). Revise the dimensions, elevation, device layout and air piping schematics based on the actual number of pumps. The outdoor power and control cabinets are shown back-to-back in a single four door enclosure. For installations where this approach is not feasible, the designer must separate the two sections (shown as the front control panel and the back power panel), adjust enclosure depth, and provide interconnecting wiring required for the number of pumps used.

5.9 Process and Instrumentation Diagrams

Based on the number of pumps and system configuration (dry weather/wet weather), select the appropriate process and instrumentation diagrams. Revise by deleting unnecessary devices/equipment based on number of pumps. Do not renumber or adjust input/output designations. Label all unused PLC input/outputs as spare.

5.10 Control System Wiring Diagrams

Based on the number of pumps and system configuration (dry weather/wet weather) select the appropriate control system schematic diagrams. Revise by deleting unnecessary devices based on number of pumps. Do not renumber or adjust line numbers or input/output designations. Label all unused PLC input/output as spare.

5.11 MCC & Power Wiring Diagram

Select the appropriate diagram and revise to reflect actual number of pumps, valve vault exhaust fan, service voltage and other site specific conditions

5.12 Single Line Diagrams

Based on the location of the motor controls and the instrumentation level, select the appropriate diagram. Revise the selected single line diagram to reflect actual number of pumps, service voltage, use of a valve vault, use of a lighting transformer, etc. Coordinate service entrance and metering requirements with utility service provider

5.13 Conduit Schedule

Prepare a site specific conduit schedule by revising the following columns from the appropriate guideline sheet:

- Conduit Number
- Description
- Service (Voltage and Amps / HP)
- Routing (From, To, Via)
- Conduit Description and Size
- Cable or Wire Description and Conductor Size

Revise the table to provide conduit and wire sizes and descriptions in accordance with NEC requirements for actual site conditions. Conduits not necessary at a specific site should be deleted from the schedule. Show conduits to be installed for future use as "Installed Spare" or "Future Space" on the Schedule.

Notes to the Design Engineer are provided to assist the designer in selecting conduits for certain special installations. Revise the conduit schedule selected based on the appropriate notes. Delete the notes from the final document.

5.14 Device Ratings Schedule

Prepare a site specific device ratings schedule by including the following columns from the appropriate sheets:

- Item
- Circuit
- Description
- Rating (Select the column that corresponds to the number and size of pumps at the site.)

All pump sizes are specified in standard motor horsepower. For submersible pumps that do not precisely coordinate with these standard horsepower, select the table for the next larger size.

Verify that device ratings selected are in accordance with current NEC requirements.

5.15 MCC Elevation

For sites that include a MCC, include the MCC elevation specified on the device rating schedule for the appropriate number of pumps, and horsepower ratings required.

APPENDIX A

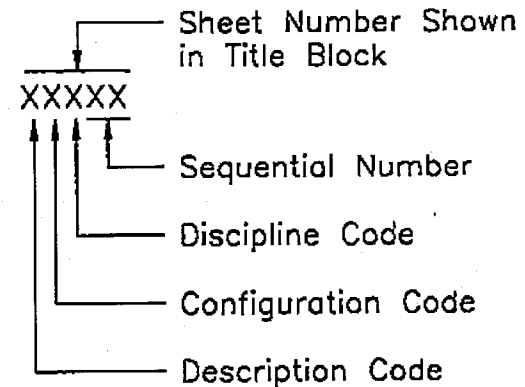
GENERAL DRAWING/FILE INFORMATION

City of Houston
 Design Guideline Drawings
 For Submersible Lift Stations
 Filename & Sheet Numbering Designation Codes

Description Codes

- A - 2-Pump Station 100 gpm per Pump
- B - 2-Pump Station 100-300 gpm per Pump
- C - 2-Pump Station 250-500 gpm per Pump
- D - 3-Pump Station 250-2000 gpm per Pump
- E - 3-Pump Station 2000-5300 gpm per Pump
- F - 4-Pump Station 500-2500 gpm per Pump
- G - 5-Pump Station 2 Dry & 3 Wet Weather Pumps
- H - 6-Pump Station 2 Dry & 4 Wet Weather Pumps
- I - Open
- J - Open
- K - Open
- L - Open
- M - Open
- N - Open
- O - Open
- P - Open
- Q - Open
- R - Open
- S - Open
- T - Open
- U - Open
- V - Open
- W - Level I Instrumentation
- X - Level II Instrumentation
- Y - Level III Instrumentation
- Z - Common Drawings

Filename Designation



Discipline Codes

- A - Architectural
- C - Civil
- E - Electrical & Instrumentation
- G - General
- S - Structural

Configuration Codes

- 0 - Dwg Non-Specific to Configuration
- 1 - Alternate High Profile Configuration
- 2 - Preferred Configuration
- 3 - Alternate Low Profile Configuration

Figure A-1

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
Z0G01	Title Page
Z0A01	Control Building, Architectural
A1C01	Plan View @ Grade & Sections, 2--Pumps @ 100 gpm per Pump, Alternate High Profile Configuration
A1C02	Elevation Sections, 2--Pumps @ 100 gpm per Pump, Alternate High Profile Configuration
A2C01	Plan View @ Grade & Sections, 2--Pumps @ 100 gpm per Pump, Preferred Configuration
A2C02	Elevation Sections, 2--Pumps @ 100 gpm per Pump, Preferred Configuration
A3C01	Plan View @ Grade & Sections, 2--Pumps @ 100 gpm per Pump, Alternate Low Profile Configuration
A3C02	Elevation Sections, 2--Pumps @ 100 gpm per Pump, Alternate Low Profile Configuration
B1C01	Plan View @ Grade & Sections, 2--Pumps @ 100 - 300 gpm per Pump, Alternate High Profile Configuration
B1C02	Elevation Section, 2--Pumps @ 100 - 300 gpm per Pump, Alternate High Profile Configuration
B2C01	Plan View @ Grade & Sections, 2--Pumps @ 100 - 300 gpm per Pump, Preferred Configuration
B2C02	Elevation Section, 2--Pumps @ 100 - 300 gpm per Pump, Preferred Configuration
B3C01	Plan View @ Grade & Sections, 2--Pumps @ 100 - 300 gpm per Pump, Alternate Low Profile Configuration
B3C02	Elevation Section, 2--Pumps @ 100 - 300 gpm per Pump, Alternate Low Profile Configuration
C1C01	Plan View @ Grade & Base Sect, 2--Pumps @ 250 - 500 gpm per Pump, Alternate High Profile Configuration
C1C02	Elevation Section, 2--Pumps @ 250 - 500 gpm per Pump, Alternate High Profile Configuration
C2C01	Plan View @ Grade & Base Sect, 2--Pumps @ 250 - 500 gpm per Pump, Preferred Configuration
C2C02	Elevation Section, 2--Pumps @ 250 - 500 gpm per Pump, Preferred Configuration
C3C01	Plan View @ Grade & Base Sect, 2--Pumps @ 250 - 500 gpm per Pump, Alternate Low Profile Configuration
C3C02	Elevation Section, 2--Pumps @ 250 - 500 gpm per Pump, Alternate Low Profile Configuration
D1C01	Plan View @ Grade & Base Sect, 3--Pumps @ 250 - 2000 gpm per Pump, Alternate High Profile Configuration
D1C02	Elevation Section, 3--Pumps @ 250 - 2000 gpm per Pump, Alternate High Profile Configuration
D2C01	Plan View @ Grade, 3--Pumps @ 250 - 2000 gpm per Pump, Preferred Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
D2C02	Elevation Section, 3-Pumps @ 250 – 2000 gpm per Pump, Preferred Configuration
D2C03	Base Section, 3-Pumps @ 250 – 2000 gpm per Pump, Preferred Configuration
D3C01	Plan View @ Grade, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate Low Profile Configuration
D3C02	Elevation Section, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate Low Profile Configuration
D3C03	Base Section, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate Low Profile Site Configuration
E1C01	Plan View @ Grade, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate High Profile Configuration
E1C02	Elevation Section, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate High Profile Configuration
E1C03	Base Section, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate High Profile Configuration
E2C01	Plan View @ Grade, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E2C02	Elevation Section, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E2C03	Sections, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E3C01	Plan View @ Grade, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3C02	Elevation Section, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3C03	Base Section, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
F1C01	Plan View @ Grade, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F1C02	Elevation Section, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F1C03	Base Section, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F2C01	Plan View @ Grade, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F2C02	Elevation Section, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F2C03	Base Section, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F3C01	Plan View @ Grade, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3C02	Elevation Section, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3C03	Base Section, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
G1C01	Plan View @ Grade, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
G1C02	Elevation Section, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
G1C03	Base Section, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
G2C01	Plan View @ Grade, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G2C02	Elevation Section, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G2C03	Base Section, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G2C04	Station Operation Tables, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G3C01	Plan View @ Grade, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3C02	Elevation Section, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3C03	Base Section, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3C04	Station Operation Tables, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H1C01	Plan View @ Grade, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H1C02	Elevation Section, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H1C03	Base Section, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H2C01	Plan View @ Grade, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H2C02	Elevation Section, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H2C03	Base Section, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H2C04	Station Operation Tables, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H3C01	Plan View @ Grade, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3C02	Elevation Section, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3C03	Base Section, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3C04	Station Operation Tables, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
Z0C01	Air Cell Assembly & Details
Z0C02	Typical Details, Civil
Z0C03	Typical Details, Civil
Z0C04	Discharge Piping Support Details
Z0C05	Catwalk Details
Z0C06	Surge Relief Valve Details
Z0C07	Typical Details, Civil
Z0C08	Typical Site Details
Z0C09	Example – Site Plan
A1S01	Structural, 2-Pumps @ 100 gpm per Pump, Alternate High Profile Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
A2S01	Structural, 2-Pumps @ 100 gpm per Pump, Preferred Configuration
A3S01	Structural, 2-Pumps @ 100 gpm per Pump, Alternate Low Profile Configuration
B1S01	Structural, 2-Pumps @ 100 - 300 gpm per Pump, Alternate High Profile Configuration
B2S01	Structural, 2-Pumps @ 100 - 300 gpm per Pump, Preferred Configuration
B3S01	Structural, 2-Pumps @ 100 - 300 gpm per Pump, Alternate Low Profile Configuration
C1S01	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Alternate High Profile Configuration
C1S02	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Alternate High Profile Configuration
C2S01	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Preferred Configuration
C2S02	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Preferred Configuration
C2S03	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Preferred Configuration
C3S01	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Alternate Low Profile Configuration
C3S02	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Alternate Low Profile Configuration
C3S03	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Alternate Low Profile Configuration
D1S01	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Alternate High Profile Configuration
D1S02	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Alternate High Profile Configuration
D2S01	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Preferred Configuration
D2S02	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Preferred Configuration
D2S03	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Preferred Configuration
D2S04	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Preferred Configuration
D3S01	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Alternate Low Profile Configuration
D3S02	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Alternate Low Profile Configuration
D3S03	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Alternate Low Profile Configuration
D3S04	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Alternate Low Profile Configuration
E1S01	Structural, 3-Pumps @ 2000 - 5300 gpm per Pump, Alternate High Profile Configuration
E1S02	Structural, 3-Pumps @ 2000 - 5300 gpm per Pump, Alternate High Profile Configuration
E1S03	Structural, 3-Pumps @ 2000 - 5300 gpm per Pump, Alternate High Profile Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
E2S01	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E2S02	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E2S03	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E2S04	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E3S01	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3S02	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3S03	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3S04	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
F1S01	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F1S02	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F1S03	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F2S01	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F2S02	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F2S03	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F2S04	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F3S01	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3S02	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3S03	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3S04	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
G1S01	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
G1S02	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
G1S03	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
G2S01	Structural, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G2S02	Structural, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G2S03	Structural, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G2S04	Structural, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G3S01	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3S02	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
G3S03	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3S04	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H1S01	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H1S02	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H1S03	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H2S01	Structural, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H2S02	Structural, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H2S03	Structural, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H2S04	Structural, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H3S01	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3S02	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3S03	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3S04	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
Z0S01	Structural – Typical Details
Z0S02	Structural – General Notes
A1E01	Conduit Layout, 2-Pumps @ 100 gpm per Pump, Alternate High Profile Configuration
A2E01	Conduit Layout, 2-Pumps @ 100 gpm per Pump, Preferred Configuration
A3E01	Conduit Layout, 2-Pumps @ 100 gpm per Pump, Alternate Low Profile Configuration
B1E01	Conduit Layout, 2-Pumps @ 100 – 300 gpm per Pump, Alternate High Profile Configuration
B2E01	Conduit Layout, 2-Pumps @ 100 – 300 gpm per Pump, Preferred Configuration
B3E01	Conduit Layout, 2-Pumps @ 100 – 300 gpm per Pump, Alternate Low Profile Configuration
C1E01	Conduit Layout, 2-Pumps @ 250 – 500 gpm per Pump, Alternate High Profile Configuration
C2E01	Conduit Layout, 2-Pumps @ 250 – 500 gpm per Pump, Preferred Configuration
C3E01	Conduit Layout w/JB Outside Valve Vault, 2-Pumps @ 250 – 500 gpm per Pump, Alternate Low Profile Configuration
C3E02	Conduit Layout w/JB Inside Valve Vault, 2-Pumps @ 250 – 500 gpm per Pump, Alternate Low Profile Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
C3E03	Conduit Layout Sections, 2-Pumps @ 250 – 500 gpm per Pump, Alternate Low Profile Site Configuration
D1E01	Conduit Layout, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate High Profile Configuration
D2E01	Conduit Layout, 3-Pumps @ 250 – 2000 gpm per Pump, Preferred Configuration
D3E01	Conduit Layout w/JB Outside Valve Vault, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate Low Profile Configuration
D3E02	Conduit Layout w/JB Inside Valve Vault, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate Low Profile Configuration
D3E03	Conduit Layout Sections, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate Low Profile Configuration
E1E01	Conduit Layout, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate High Profile Configuration
E2E01	Conduit Layout, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E3E01	Conduit Layout w/JB Outside Valve Vault, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3E02	Conduit Layout w/JB Inside Valve Vault, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3E03	Conduit Layout Sections, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
F1E01	Conduit Layout, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F2E01	Conduit Layout, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F3E01	Conduit Layout w/JB Outside Valve Vault, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3E02	Conduit Layout w/JB Inside Valve Vault, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3E03	Conduit Layout Sections, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
G1E01	Conduit Layout, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
G2E01	Conduit Layout, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G3E01	Conduit Layout w/JB Outside Valve Vault, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3E02	Conduit Layout w/JB Inside Valve Vault, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3E03	Conduit Layout Elevations, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3E04	Conduit Layout Sections, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3E05	Conduit Layout Sections, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
H1E01	Conduit Layout, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H2E01	Conduit Layout, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H3E01	Conduit Layout w/JB Outside Valve Vault, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3E02	Conduit Layout w/JB Inside Valve Vault, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3E03	Conduit Layout Elevations, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3E04	Conduit Layout Sections, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3E05	Conduit Layout Sections, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
W0E01	Level I Instrumentation, Outdoor Control Cabinet Installation & Air Piping Schematic
W0E02	Level I Instrumentation, Outdoor Control Panel Equipment Layout & Schedule
W0E10	Level I Instrumentation, Single Phase, Control Cabinet Equipment Layout
W0E11	Level I Instrumentation, Single Phase, Control Cabinet Equipment Layout
W0E12	Level I Instrumentation, Single Phase, Single Line, & Power Wiring Diagrams
W0E13	Level I Instrumentation, Single Phase, Control Wiring Diagram
W0E14	Level I Instrumentation, Single Phase, Control Wiring Diagram
W0E15	Level I Instrumentation, Single Phase, Alternate Control Wiring Diagram
W0E20	Level I Instrumentation, Three Phase, Control Cabinet Equipment Layout
W0E21	Level I Instrumentation, Three Phase, Control Cabinet Equipment Layout
W0E22	Level I Instrumentation, Three Phase, Single Line, & Power Wiring Diagrams
W0E23	Level I Instrumentation, Three Phase, Control Wiring Diagram
W0E24	Level I Instrumentation, Three Phase, Control Wiring Diagram
W0E25	Level I Instrumentation, Three Phase, Alternate Control Wiring Diagram
W0E30	Level I Instrumentation, Control System Process & Instrumentation Diagram
X0E01	Level II Instrumentation, Outdoor Control Cabinet Installation & Air Piping Schematic
X0E02	Level II Instrumentation, Outdoor Control Cabinet Equipment Layout & Schedule
X0E03	Level II Instrumentation, Outdoor Control Cabinet Equipment Layout
X0E04	Level II Instrumentation, Outdoor Control Cabinet Equipment Layout
X0E05	Level II Instrumentation, Outdoor Control Cabinet Equipment Layout

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
X0E06	Level II Instrumentation, Outdoor Panel, Power Wiring Diagram
X0E10	Level II Instrumentation, Outdoor Power Panel, Single Line Diagram
X0E21	Level II Instrumentation, Indoor Control Cabinet Layout & Air Piping Schematic
X0E22	Level II Instrumentation, Indoor Control Cabinet Equipment Layout
X0E23	Level II Instrumentation, Indoor Control Cabinet Equipment Layout
X0E24	Not Used
X0E25	Level II Instrumentation, Indoor Panel, MCC Power Schematic & Wiring Diagram
X0E28	Level II Instrumentation, Indoor Panel, Single Line Diagram
X0E40	Level II Instrumentation, Outdoor Panel, Control System Process & Instrumentation Diagram
X0E41	Level II Instrumentation, Outdoor Panel, Control System Process & Instrumentation Diagram
X0E50	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E51	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E52	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E53	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E54	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E55	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E56	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E57	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E58	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E60	Level II Instrumentation, Indoor Panel, Control System Process & Instrumentation Diagram
X0E61	Level II Instrumentation, Indoor Panel, Control System Process & Instrumentation Diagram
X0E70	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E71	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E72	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E73	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E74	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E75	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E76	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
X0E77	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E78	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
Y0E20	Level III Instrumentation, Air Piping Schematic
Y0E21	Level III Instrumentation, Control Cabinet Layout & Equipment Schedule
Y0E22	Level III Instrumentation, Control Cabinet Equipment Layout
Y0E23	Level III Instrumentation, Control Cabinet Equipment Layout
Y0E24	Not Used
Y0E25	Not Used
Y0E26	Level III Instrumentation, MCC Power Schematic, Control Power & Communications Wiring Diagram
Y0E30	Level III Instrumentation, Single Line Diagram
Y0E40	Level III Instrumentation, Control System Process & Instrumentation Diagram
Y0E41	Level III Instrumentation, Control System Process & Instrumentation Diagram
Y0E50	Level III Instrumentation, Control Wiring Diagram
Y0E51	Level III Instrumentation, Control Wiring Diagram
Y0E52	Level III Instrumentation, Control Wiring Diagram
Y0E53	Level III Instrumentation, Control Wiring Diagram
Y0E54	Level III Instrumentation, Control Wiring Diagram
Y0E55	Level III Instrumentation, Control Wiring Diagram
Y0E56	Level III Instrumentation, Control Wiring Diagram
Y0E57	Level III Instrumentation, Control Wiring Diagram
Y0E58	Level III Instrumentation, Control Wiring Diagram
Y0E59	Level III Instrumentation, Control Wiring Diagram
Y0E60	Level III Instrumentation, Control Wiring Diagram
Z0E01	Electrical Symbols, Legend, Lighting Fixture Symbols & Abbreviations
Z0E02	Typical Junction Box Details
Z0E03	Typical Details, Instrumentation/Electrical
Z0E04	Typical Details, Instrumentation/Electrical
Z0E05	Control Building, Instrumentation/Electrical
Z0E06	Example – Electrical Site Plan

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
Z0E10	Level II or III Instrumentation, MCC Elevations
Z0E11	Level II or III Instrumentation, MCC Elevations
Z0E12	Level II or III Instrumentation, MCC Elevations
Z0E13	Level II or III Instrumentation, MCC Elevations
Z0E14	Level II or III Instrumentation, MCC Elevations
Z0E15	Level II or III Instrumentation, MCC Elevations
Z0E20	Level II or III Instrumentation, Conduit Schedules for 240V System
Z0E21	Level II or III Instrumentation, Conduit Schedules for 480V System
Z0E40	Level II or III Instrumentation, Device Ratings Schedules for 240V System
Z0E41	Level II or III Instrumentation, Device Ratings Schedules for 480V System
Z0E42	Level II or III Instrumentation, Device Ratings Schedules for 480V System
Z0E43	Level II or III Instrumentation, Device Ratings Schedules for 480V System
Z0E44	Level II or III Instrumentation, Device Ratings Schedules for 480V System

City of Houston Standard Drawings - CADD File Layering (Level) Breakdown

All Text and Text related line entities (i.e. Dimension & Leader Lines, Cross Section Lines, etc.) are placed on the layers beginning with 'T'; and each entity is placed on the layer corresponding to its color.

Example:

<u>Layer Name</u>	<u>Color</u>	<u>Linetype</u>	<u>Description</u>
TXT-1	1 (red)	Continuous	Text, Dim & Ldr lines which are red
TXT-2	2 (yellow)	Continuous	Text, Dim & Ldr lines which are yellow
TXT-3	3 (green)	Continuous	Text, Dim & Ldr lines which are green
TXT-4	4 (cyan)	Continuous	Text, Dim & Ldr lines which are cyan

All Other entities are placed on layers beginning with 'L'; and each entity is placed on the layer corresponding to its color and linetype.

Example:

<u>Layer Name</u>	<u>Color</u>	<u>Linetype</u>	<u>Description</u>
LCON-1	1 (red)	Continuous	Other entities which are Red & Continuous Lines
LCON-2	2 (yellow)	Continuous	Other entities which are Yellow & Continuous Lines
LCON-3	3 (green)	Continuous	Other entities which are Green & Continuous Lines
LCON-4	4 (cyan)	Continuous	Other entities which are Cyan & Continuous Lines
LCTR-1	1 (red)	Center	Other entities which are Red & Center Lines
LCTR-2	2 (yellow)	Center	Other entities which are Yellow & Center Lines
LCTR-3	3 (green)	Center	Other entities which are Green & Center Lines
LCTR-4	4 (cyan)	Center	Other entities which are Cyan & Center Lines
LDAS-1	1 (red)	Dashed	Other entities which are Red & Dashed Lines
LDAS-2	2 (yellow)	Dashed	Other entities which are Yellow & Dashed Lines
LDAS-3	3 (green)	Dashed	Other entities which are Green & Dashed Lines
LDAS-4	4 (cyan)	Dashed	Other entities which are Cyan & Dashed Lines
LHID-1	1 (red)	Hidden	Other entities which are Red & Hidden Lines
LHID-2	2 (yellow)	Hidden	Other entities which are Yellow & Hidden Lines
LHID-3	3 (green)	Hidden	Other entities which are Green & Hidden Lines
LHID-4	4 (cyan)	Hidden	Other entities which are Cyan & Hidden Lines

Other layers or levels may exist; i.e. LMHID-4, LSDAS-1, etc. The last digit represents the color no. & the digits between L and the last digit represent the entity linetype. Unused layers have been purged from the drawing file.

Suggested Color to Line Weights

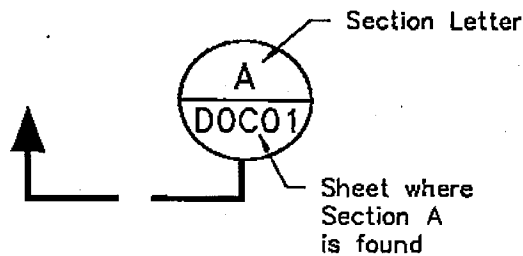
<u>Color</u>	<u>Line Weight</u>
1 (red)	0.35 mm
2 (yellow)	0.50 mm
3 (green)	0.70 mm
4 (cyan)	0.25 mm
5 (blue)	0.25 mm
6 (magenta)	0.35 mm
7 (white)	0.50 mm
8 (grey)	0.35 mm
9 (rust)	0.35 mm
10 (gold)	0.25 mm
11 (avocado)	0.25 mm

Figure A-3

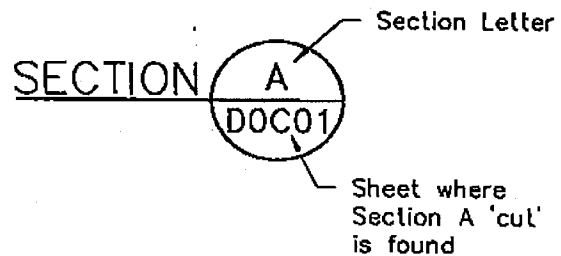
EXPLANATION OF SECTION & DETAIL INDICATORS FOR COH LIFT STATION DESIGN GUIDELINE DRAWINGS

Section Indicators

Indicator on Field of Dwg ('Cut'):

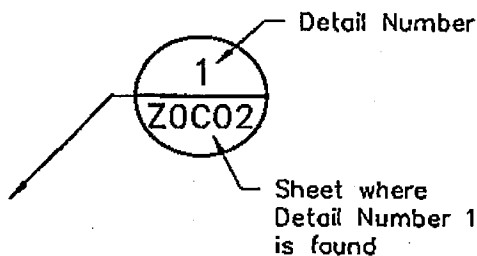


Indicator at Section:

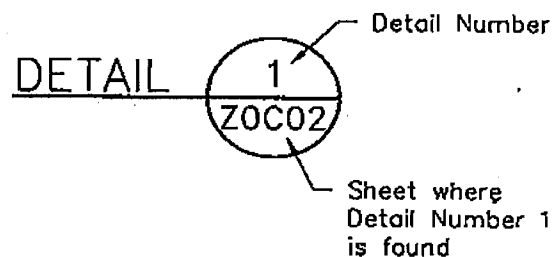


Detail Indicators

Indicator on Field of Dwg (Callout):



Indicator at Detail:



Note:

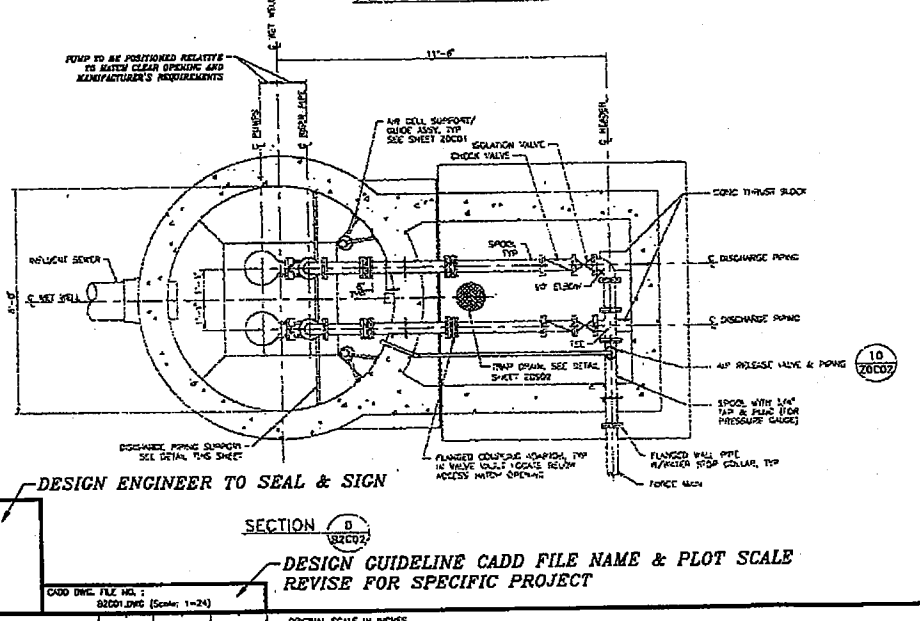
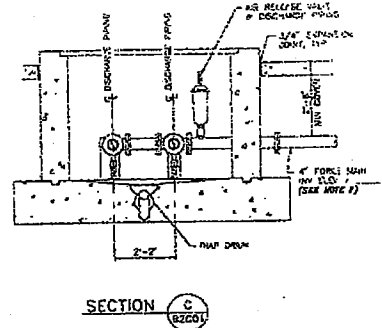
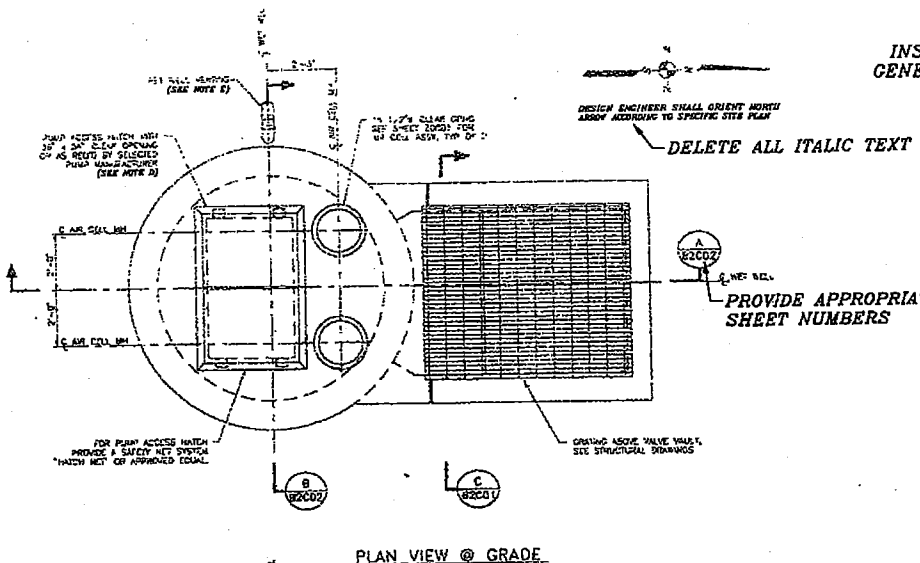
Details are not referenced back to the sheet(s) where they are called out on the Field of Dwg. These references would be numerous, and locations redundant in relation to each separate lift station configuration.

Notes:

The sheet number is located in the lower right corner of the drawing Title Block in the space labeled "DWG NO."

The sheet numbers called out on the Design Guideline Drawings are for the purposes of referencing information in the Design Guideline Drawing package. The Design Engineer shall revise all sheet number references to reflect the appropriate sheet number in his project drawing package.

**FIGURE A-5
INSTRUCTIONS FOR REVISING
GENERAL DRAWING INFORMATION
- EXAMPLE -**



DESIGN ENGINEER TO READ NOTES FOR PERTINENT INFORMATION THEN DELETE

MOVE TO TOP OF SHEET

- NOTES TO DESIGN ENGINEER:**
- THESE LIFT STATION DRAWINGS ARE CONSIDERED TO BE DESIGN GUIDELINES FOR THE CONSTRUCTION OF CITY OF HOUSTON WASTEWATER SUBMERSIBLE LIFT STATIONS. THESE DRAWINGS ARE TO BE USED AS FRAMEWORK FOR THE CONTRACTED DESIGN ENGINEER IN DEVELOPING SPECIFIC LIFT STATION DETAILS. IT IS THE RESPONSIBILITY OF THE CONTRACTED DESIGN ENGINEER TO VERIFY THE COMPLETENESS AND ACCURACY OF THE INFORMATION BEING OBTAINED AND TO ADJUST ACCORDING TO SPECIFIC SITE REQUIREMENTS.
 - THIS DESIGN IS BASED UPON THE LARGEST CAPACITY PUMP FOR THIS STATION (NAME: 300 - 300 LPM PER PUMP).
 - LIFT STATION DESIGN IS BASED UPON NOMINAL 4" PUMP VALVES AND PIPING AS THIS DESIGN IS ACCREDITED FOR THIS STANDARD STATION. THE DESIGN WILL REQUIRE A MINIMUM 4" PUMP VALVES AND PIPING IF SPECIFIC SITE CONDITIONS REQUIRE.
 - DESIGN ENGINEER TO VERIFY THE SIZE AND LOCATION OF THE WET WELL MANHOLES ACCORDING TO THE MANHOLE PUMP AND PUMP MANUFACTURER'S REQUIREMENTS.
 - THE ACTUAL LOCATION OF THE WET WELL VENTING MAY VARY ACCORDING TO SITE REQUIREMENTS. VERIFY PUMPING LOCATES ON THE HORIZONTAL PLAN OF THE WET WELL.
 - AVAILABILITY AND INFORMATION OBTAINED ARE DETERMINED BY DESIGN ENGINEER PER SPECIFIC SITE REQUIREMENTS.
 - SEE DETAIL AND STRUCTURAL DRAWINGS FOR DIMENSIONS AND INFORMATION NOT SHOWN.
 - THE DESIGN ENGINEER SHALL SUBMIT APPROPRIATE GUYE THE NECESSARY STANDARD OUTLINE DRAWINGS AND DETAILS INTO GUYE PAPER FOR GUYE CONSULTATION AND SHALL ADVISE PUMP MANUFACTURER AND CROSS REFERENCING ACCORDANTLY.
 - THE DESIGN ENGINEER SHALL CONSULT THE CITY OF HOUSTON DESIGN GUIDELINE MANUAL, THE MANHOLE DESIGN MANUAL AND THE MASTER SPECIFICATIONS FOR PUMP CONSTRUCTION AND INFORMATION PERTAINING TO THESE STANDARD DESIGN GUIDELINE DRAWINGS.
 - THE DESIGN ENGINEER SHALL REMOVE THESE NOTES, ALL REFERENCES TO THESE NOTES AND ANY OTHER EXPLANATORY INFORMATION FROM THE DESIGN GUIDELINE DRAWINGS. DESIGN ENGINEER SHALL PROVIDE ANY NOTES OR OTHER APPROPRIATE INFORMATION NECESSARY TO COMPLETE THE LIFT STATION DESIGN.

- NOTES:**
- SEE DETAIL AND STRUCTURAL DRAWINGS FOR DIMENSIONS AND INFORMATION NOT SHOWN.
 - CONTRACTOR TO CONFIRM SIZE AND LOCATION OF THE WET WELL MANHOLES PER GUYE PAPER AND PUMP MANUFACTURER'S REQUIREMENTS.
- PROVIDE ADDITIONAL NOTES AS REQUIRED**

REPLACE WITH APPROPRIATE DESCRIPTION OF INFORMATION CONTAINED ON SHEET

REPLACE WITH SPECIFIC PROJECT NUMBER

REPLACE WITH SPECIFIC PROJECT TITLE

PROVIDE SHEET NOS. ACCORDING TO PLACEMENT IN SPECIFIC PROJECT DRAWING PACKAGE

DELETE GUIDELINE DRAWING NO.

VERIFY DRAWING SCALE

ENTER CURRENT DATE

PLAN VIEW @ GRADE & SECTIONS 2 PUMPS @ 100 - 300 GPM PER PUMP LOW PROFILE, SECURED SITE CONFIGURATION
PROJECT NO. R-0267-02-2
TITLE CITY OF HOUSTON DESIGN GUIDELINE DRAWINGS FOR SUBMERSIBLE LIFT STATIONS
CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING ENGINEERING, CONSTRUCTION AND REAL ESTATE GROUP
APPROVALS
WATER DESIGN WHITE AND SIGNAL DESIGN
STORM SEWER DESIGN STREET, BRIDGE & PLAV.
WASTEWATER DESIGN CONSTRUCTION
OTHER REVIEWS
PLANNING AND DEVELOPMENT
CITY ENGINEER DATE
SCALE 1/2" = 1'-0" DESIGNED BY
SUBMITTED DRAWING NO.
DATE DECEMBER, 1992 SHEET NO. OF SHEETS
DRAWN BY DATE NO. B2C01
REV. NO. DESCRIPTION APP'D DATE
READ BOOK NO.

APPENDIX B

STRUCTURAL DESIGN CALCULATIONS

STRUCTURAL DESIGN CALCULATIONS

Introduction:

The Design Engineer shall consult the City of Houston Design Guidelines Manual, the Engineering Design Manual and the Master Specifications for performing Structural Design Calculations.

Attached Structural Design Calculations were in conformity with the Engineering Design Manual for standard submersible lift stations. The Design Engineer shall revise or adjust these calculations to meet project specific requirements. These calculations shall be part of the Structural Design Calculations for a specific project.

STRUCTURAL DESIGN CALCULATIONS

INDEX

<u>Title</u> <u>No.</u>		<u>Sheet</u> <u>No.</u>
1.	Caisson Construction of Wet Well	1
2.	Baffle Wall at Wet Well	2
3.	Thrust Blocks	3
4.	Connections	4
5.	2 Pumps - 100 - 300 gpm per pump	7
6.	2 Pumps - 250 - 500 gpm per pump	18
7.	3 Pumps - 250 - 2000 gpm per Pump	24
8.	3 Pumps - 2000 - 5300 gpm per Pumps	31
9.	4 Pumps - 500 - 2500 gpm per Pumps	43
10.	5 Pumps - 3 Wet and 2 Dry Weather per Pumps	51
11.	6 Pumps - 4 Wet and 2 Dry Well per Pumps	67
12.	Control Building	82



CITY OF HOUSTON		3907-02
PROJECT	JOB NO 0101	
2-PUMP LIFT STATION		11
SUBJECT	SHEET	
NMP	1-6-95	
DESIGNED	DATE	CHECKED
		DATE

"CAISSON CONSTRUCTION" of Wet well: Alternate Method: Precast Concrete Design & Construct-^{ion}

The contractor, at his option, may select to utilize precast concrete units for "Caisson Construction" method. He will confirm to the City of Houston Engineering Manual for Standard Pump Station Design, Section 3 - Structural Design Criteria and the following requirements:

1. Precast concrete design calculations and drawings shall be prepared under the supervision of and sealed by an engineer registered in the State of Texas.
2. Precast units shall be designed to resist lateral pressure due to tilting during sinking.
3. Connections between units shall be designed to transfer shear due to tilting and tension due to hang-up forces due to adhesion/friction between caisson wall and adjacent soil.
4. All joints between precast units shall be watertight.
5. All costs related to alternate method shall be at the contractor's expense.

8 inch thick Baffle wall w/ Port holes in bottom:

Assume. 2-6" x 1'-0 to 1'-6" wide opngs.
Differential water depth
if port holes get blocked.

$$h_w = 4' \text{ max.}$$

$$M = \frac{0.063 \times 4^3}{6} = 0.7 \text{ k/ft} \quad M_u = 1.5 \text{ k/ft}$$

$$V = 0.063 \times 4^2 = 0.5 \text{ k/ft} \quad V_u = 0.85 \text{ k/ft}$$

$t = 8''$ wall

$$d = 4'' \quad F = 0.016$$

Assume 50% wall remain
w/ port holes.

$$K_n = \frac{1.5 \times 2}{0.016} = 188$$

$$\rho = 0.0036$$

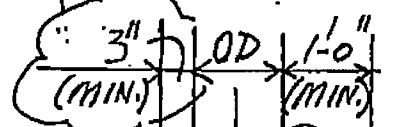
$A_s = 0.17 \text{ in}^2/\text{ft}$ #4 @ 12 Vert
in mid thickness of 8" wall.
#4 @ 12 Hori.



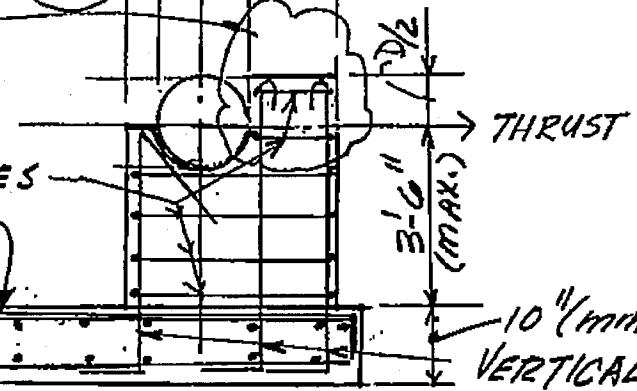
City of Houston		3904-00	
PROJECT	Thrust Blocks	JOB NO. 0101	
SUBJECT		SHEET 10	
NMP DESIGNED	1-5-95	CHECKED	DATE

Thrust blocks For 8", 12", 16" and 20" ID PIPE with Operating pressure 50 psi (max). (115' A Head).

REVISED 1-16-95



REVISED 1-6-95

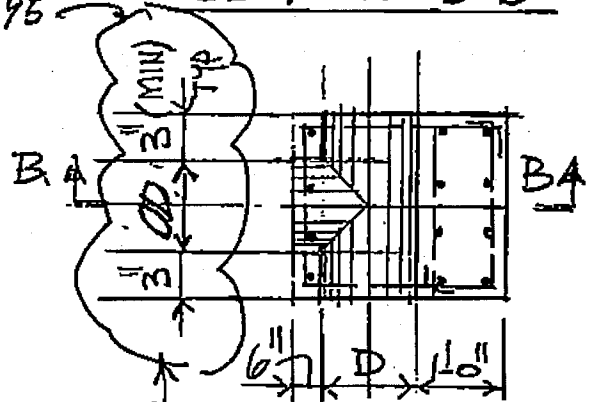


#588 #5x6'8" ADDL FOR 16" & 20" DIA. PIPE PAD

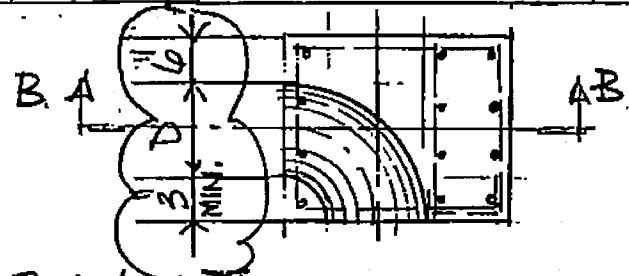
REVISED 1-16-95

SECTION B-B.

PIPE DIA.	No. OF VERT BARS
8"	3-2 #5
12"	3-3 #5
16"	3-4 #5
20"	3-4 #5



PLAN - THRUST BLOCK AT TEE



PLAN - THRUST BLOCK AT ELBOW

Pat - Please Delete Pipe Thrust block shown on S-22 and Add above details instead.

CONNECTIONS

Table 6.20.8 Shear strength of welded headed studs

I—Design shear strength limited by concrete:

Use smaller of the values from Eqs. 6.5.8a and 6.5.9

$$\phi V_c = (\phi 628 d_s^2 \lambda \sqrt{f'_c}) n \quad (\text{Eq. 6.5.8a}) \quad \text{for } d_c > 15d_s$$

Table A gives values for $n = 1, \phi = 0.85$

$$\phi V_c = \phi V'_c C_w C_l C_c \quad (\text{Eq. 6.5.9}) \quad \text{for } d_c < 15d_s$$

where:

$$\phi V'_c = \phi 12.5 d_s^{1.5} \lambda \sqrt{f'_c}$$

$$C_w = \left(1 + \frac{b}{3.5 d_s} \right) \leq n_s$$

$$C_l = \frac{h}{1.3 d_s} \leq 1.0$$

$$C_c = \left[0.4 + 0.7 \left(\frac{d_c}{d_s} \right) \right] \leq 1.0$$

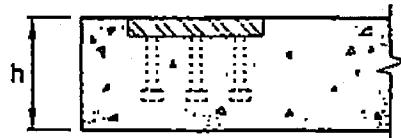
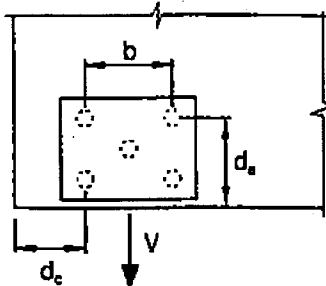


Table B gives values for $\phi = 0.85$

where: n_s = number of studs in back row; see figure for other notation

II—Design shear strength limited by steel:

$$\phi V_s = (\phi 35,344 d_s^2) n \quad (\text{Eq. 6.5.14a})$$

Table C gives value for $n = 1, \phi = 1.0$

$f_s = 60 \text{ ksi}$
 $35,344 = 0.75 \times 60,000 \times \frac{\pi}{4}$

Table A— ϕV_c , kips

f'_c , psi	4000		5000		6000		7000		8000		
	λ	1.0	0.85	1.0	0.85	1.0	0.85	1.0	0.85	1.0	0.85
d_b , in. $\frac{1}{4}$		2.15	1.83	2.40	2.04	2.63	2.24	2.85	2.42	3.04	2.58
$\frac{3}{8}$		4.74	4.03	5.30	4.51	5.81	4.94	6.28	5.33	6.71	5.70
$\frac{1}{2}$		8.43	7.16	9.45	8.03	10.32	8.78	11.15	9.48	11.82	10.13
$\frac{3}{4}$		13.19	11.21	14.72	11.79	16.15	13.72	17.44	14.83	18.65	15.85
$\frac{1}{2}$		19.00	16.14	21.23	18.04	23.26	19.77	25.12	21.35	26.85	22.82
$\frac{3}{4}$		25.85	21.97	28.90	24.56	31.66	26.91	34.19	28.09	36.55	31.07

Table B— ϕV_c , kips

d_b , in. λ	1.0	0.85	1.0	0.85	1.0	0.85	1.0	0.85	1.0	0.85
2	1.90	1.62	2.12	1.81	1.77	1.51	2.51	2.14	2.69	2.29
3	3.49	2.97	3.90	3.31	4.26	3.63	4.62	3.82	4.94	4.20
4	6.38	4.57	6.00	5.11	6.58	5.59	7.11	6.04	7.60	6.46
5	7.51	6.38	6.39	7.14	9.19	7.82	9.94	8.45	10.62	9.03
6	9.88	8.40	11.04	9.39	12.09	10.29	13.08	11.11	13.97	11.87
7	12.45	10.98	13.80	11.82	15.24	12.95	16.46	13.99	17.60	14.96
8	15.20	12.82	16.99	14.44	18.61	15.81	18.44	17.08	21.50	18.27
9	18.14	15.44	20.28	17.24	22.21	18.88	23.99	20.40	25.65	21.80
10	21.25	18.06	23.75	20.18	26.01	22.11	28.10	23.88	30.04	25.53
11	24.52	20.84	27.41	23.30	30.03	25.52	32.43	27.57	34.67	29.47
12	27.94	23.74	31.22	26.53	34.20	29.07	36.94	31.40	39.49	33.67

Table C— ϕV_s , kips

Diameter, in.	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{3}{4}$
ϕV_s	2.2	5.0	8.8	13.8	19.9	27.1

$f_s = 60 \text{ ksi}$

Ref.



PROJECT		JOB NO.	
REF: "SIMPLIFIED DESIGN"		SHEET	
SUBJECT PCA PUBL.		SHEET	
DESIGNED	DATE	CHECKED	DATE

6.5 DESIGN FOR WALL MOMENT STRENGTH

For structural walls in moderate height buildings, walls of uniform cross section with uniformly distributed vertical and horizontal reinforcement are usually the most economical. Concentration of reinforcement at the extreme ends of a wall (or wall segment) is usually not required for walls in moderate height buildings. Uniform distribution of the vertical wall reinforcement, as required for shear, will usually suffice for required moment strength. Also, minimum amount of reinforcement will usually be sufficient, not only for shear strength, but also for moment strength. Moment strength of a rectangular wall section containing uniformly distributed vertical reinforcement and subjected to combined moment and axial load can be easily calculated by:^{b.1}

$$\phi M_n = \phi [0.5 A_{st} f_y l_w (1 + \frac{P_u}{A_{st} f_y}) (1 - \frac{e}{l_w})]$$

- where A_{st} = total area of vertical wall reinforcement
 = $A_b l_w / s$ (Vertical)
 l_w = horizontal length of wall
 s = spacing of vertical wall reinforcement
 A_b = area of each bar (Vert.) or (Horiz).
 P_u = factored axial compressive load

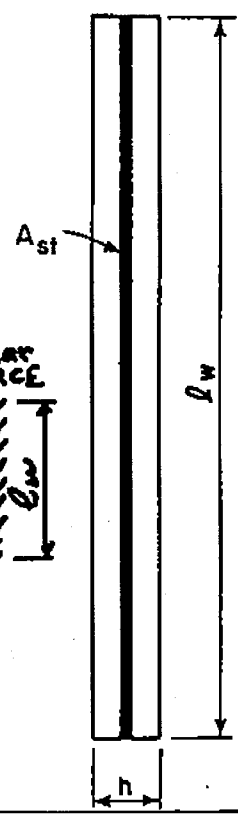
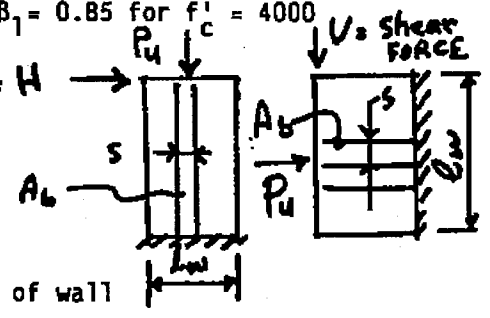
$\frac{c}{l_w} = \frac{\omega + a}{2\omega + 0.85B_1}$, where $B_1 = 0.85$ for $f'_c = 4000$

$\omega = \frac{A_{st}}{l_w h} \frac{f_y}{f'_c}$ Shear: H FORCE

$a = \frac{P_u}{l_w h f'_c}$

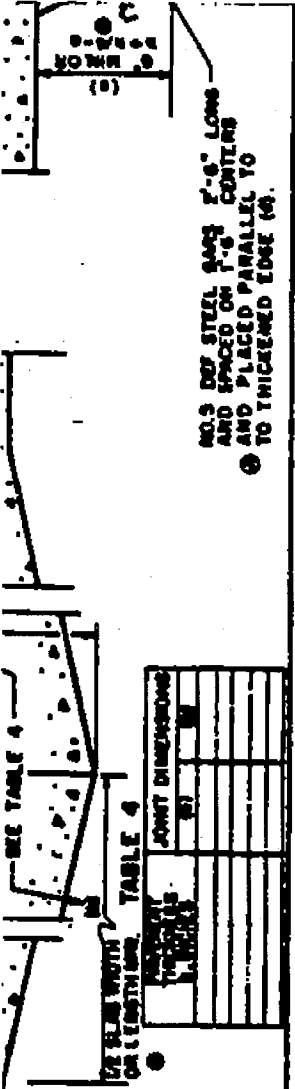
h = overall thickness of wall

$\phi = 0.90$ (strength primarily controlled by flexure with low axial load.)



3 (SEE TABLE 2)

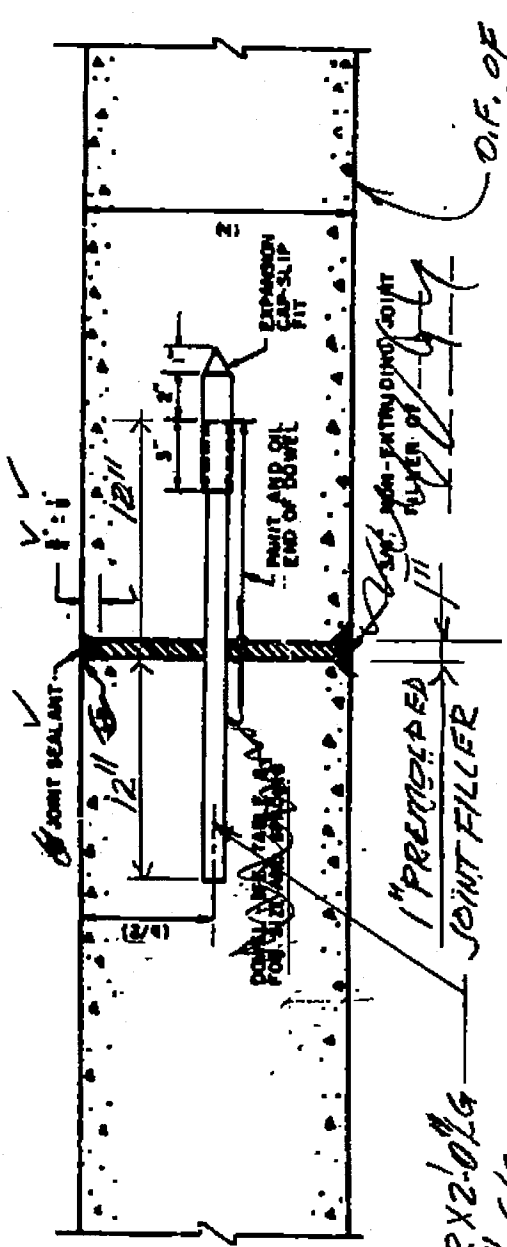
JOINT DIMENSIONS	
NO.	DESCRIPTION
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	



NO. 3 DEF STEEL BARS 2'-0" LONG AND SPACED ON 1'-0" CENTERS AND PLACED PARALLEL TO TO THICKENED EDGE (6).

EXPANSION JOINTS

TRANSVERSE



1" BAR X 2'-0" LG
@ 12" C/C.

EXPANSION JOINT - E3

REF: US Dept of Army and Air Force
 TM 5-824.3
 AFM 88-6 Chpt. 3.
 * Rigid Joints For Airfields other than Army."



HOUSTON, TX STDS		3921-00	
PROJECT LP, 55¢ PUMP STN A:2		JOB NO. 0101	
SUBJECT 2 Pumps - 100 GPM/Pump		1 OF 2 SHEET	
DESIGNED NMP	DATE 12-14-95	CHECKED	DATE

Wet well: Precast Concrete units installed by "Caisson-Sinking Method"

Max. depth = 30' 0"
 Wall t = 8" (nominal).

Consider half (t) depth gets suspended.
 Hang-up force = $0.50 \times 30' \times 0.67 \times 0.150 = 1.50 \text{ k/ft}$
 of perimeter

provide six connections (min.) per joint

V = pull-out force per connection

$$= \frac{\pi \times 6.67 \times 1.50}{6} = 5.3 \text{ k}$$

$$V_u = 1.4 \times 5.3 = 7.42 \text{ k}$$

Ref: PCI Design Handbook, 4th Ed. table 6-20.8

$$d_c = 4 \text{ in. (min.)} < 15 d_b = 7.5''$$

$$d_c = \frac{\pi \times 7.8}{6 \times 2} \approx 1.8''$$

$d_b = \frac{1}{2}''$ Dia studs

$$b = 6'' \text{ assume } h = \frac{2}{3} \times t = 5.36''$$

$$\phi V_c = 8.43 \text{ k} \times 2 = 16.86 \text{ k}$$

$$\phi V_s = 8.8 \text{ k} \times 2 = 17.6 \text{ k}$$

or $\phi V_c = \phi V_c' C_w C_t C_c$ where $\phi V_c' = 6.38$

$$= 1.43 \times 6.38$$

$$\phi V_c = 9.12 \text{ k} > V_u = 7.42$$

$$C_w = \left(1 + \frac{b}{3.5 d_c}\right) = 1.43 < 1.2$$

$$C_t = \frac{h}{1.3 d_c} = 1.03 < 1.00$$

$$C_c = 0.4 + 0.7 \left(\frac{1.8}{4}\right) = 3.55 < 1.00$$

for $5/8'' \phi$ studs
 $\phi V_c = 9.12 \text{ k}$

$$3/8'' \times 4'' \text{ weld } T = 3 \times 4 \times 24 = 36 \text{ k}$$

$$1/4'' \text{ Fillet weld } T_{\text{weld}} = \frac{1}{4} \times 6 \times 24 = 36 \text{ k}$$



CITY OF HOUSTON		3904.00
PROJECT		JOB NO. 0101
Lift Station: 2 pumps		1
SUBJECT	100-300 GPM/each.	SHEET
NMP DESIGNED	12.6-94	1.3-95
DATE		DATE
	LABOR	
	CHECKED	

Wet Well:

Inside diameter = 8'-0"
 t=12" Outside diameter = 10'-0" (ASTM C361, 102" w/t=9"
 t=12 1/2" " " = 10'-1" (ASTM C76, 102" w/t=9 1/2"
 t=13 1/4" " " = 10'-2 1/4" (" " 102" w/t=10 1/4"

Max. depth = 30 feet in ground.

Design lateral pressure = 105 psf/ft depth with surcharge lateral pressure of 100 psf for full depth.

"Sinking Caisson" method:

1. Caisson at final position. Inside water maintained to full depth, with full excavation inside completed.
Net lateral pressure, $p = (105 - 63) = 42 \text{ psf/ft}$
2. Base slab, "tremie" method completed and cured. Inside dewatered.
Net lateral pressure, $p = 105 \text{ psf/ft}$
3. Top slab in place
Net lateral pressure $p = 100 \text{ psf} + 105 \text{ psf/ft}$.

Ref: 1. ACI 318 and ACI 350 R.
 2. Structural Analysis of Shells, Baker, Kovaleski, Rish
 3. Circular Concrete tanks w/o prestressing, PCA Bulletin 57.57 (150 72.017).
 4. Formulas for stress and strain, Roark & Young

$f_c = 4,000 \text{ psi}$ - Conc. at 28 days
 $f_y = 60,000 \text{ psi}$ Reinf. ASTM A615 Gr. 60.



PROJECT		CITY OF HOUSTON	3904-00
SUBJECT		Lift Stn: 2 Pumps 100-300 GPM ca.	JOB NO. 0101
DESIGNED	DATE	12.8-94	2 SHEET
	CHECKED	AJG	1-4-95 DATE

Case I: Consider Cylindrical shell fixed at base and free at top with linear external lateral load.

REF: STRUC. ANALYSIS OF SHELLS

$$K = \frac{\sqrt{3(1-\mu^2)}}{\sqrt{RE}} = \frac{1.3027}{2} = 0.6514$$

$$KL = 19.54$$

$$\mu = 0.20$$

$$R = 4 \text{ ft}$$

$$t = 1 \text{ wall}$$

$$L = H = 30 \text{ ft.}$$

$$\lambda_1 P_1 = 100 \text{ psf}$$

$$P_2 = 3250 - 100 = 3150 \text{ psf}$$

$$\lambda_p = \frac{100}{3150} = 0.032$$

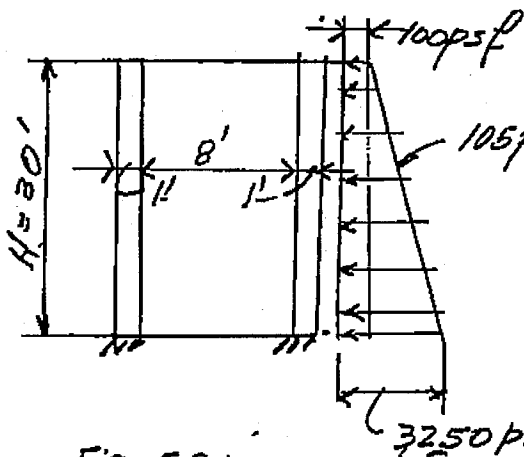


Fig 5-13 (Fixed Base)

$$M = 0.005 \times 3.10 \times 30^2 = 14.0 \text{ k-ft}$$

CONSERVATIVE μ (TENSION 0.1)

$$d = 12.5 - 2.5 = 10 \text{ in} = 0.83 \text{ ft}$$

$$M_{\text{wales}} = 1.3 \times 1.7 \times 14 = 31 \text{ k}$$

$$K_n = 344 \quad \rho = 0.0068$$

$$A_3 = 0.78 \text{ in}^2/\text{ft}$$

#6 @ 6" Vert. OF. (0.88 in²/ft)

$$\Sigma A_3 = 0.78 + 0.05 = 0.83 \text{ in}^2/\text{ft}$$

FROM UNEVEN SINKING. SHT. 4.

Fig. 5.9:

$$M_{\text{max}} = 0.001 \times 3.10 \times 30^2 = 3 \text{ k}$$

$$M_{\text{wales}} = 1.3 \times 1.7 \times 3 = 6.6 \text{ k-ft}$$

$$K_n = 74. \quad \rho = 0.0014$$

$$\rho_{\text{min}} = 0.0033$$

$$A_3 = 0.38 \text{ in}^2 \quad \#6 @ 12 \text{ Vert. IF.}$$

Fig 5.11:

$$V_{\text{max}} = 0.04 \times 3.10 \times 30 = 3.72 \text{ k-ft}$$

$$\phi V_c = 0.85 \times 2 \sqrt{4000} \times 12 \times 9.5 = 12.26 \text{ k-ft}$$

$$V_u = 3.72 \times 1.7 = 6.32 \text{ k-ft}$$



CITY OF HOUSTON		3904-00
PROJECT		JOB NO. 0101
Lift stns 2 pumps		3
SUBJECT 100-300 GPM each		SHEET
NMP	12.8.94	1-4-95
DESIGNED	DATE	DATE
	ADG	
	CHECKED	

Case II: Consider Cylindrical Shell hinged at base and free at top with linear external lateral load:

Fig. 5-10

$$M_{max} = 0.001 \times 3.1 \times 30^2 = 2.8 \text{ k/ft}$$

$$M_u = 1.3 \times 1.7 \times 2.8 = 6.2 \text{ k/ft}$$

$$K_m = 68 \quad f_{min} = 0.0038$$

$$A_3 = 0.38 \text{ in}^2/\text{ft}$$

#6 @ 12 Vert. IF.

$$V_{max} = 0.04 \times 3.1 \times 30 = 3.72 \text{ k/ft}$$

$$V_u = 1.7 \times 3.72 = 6.3 \text{ k} \quad (\phi V_c = 12.3 \text{ k/ft})$$

Consider "Sinking Caisson" method:
Hung-up forces:

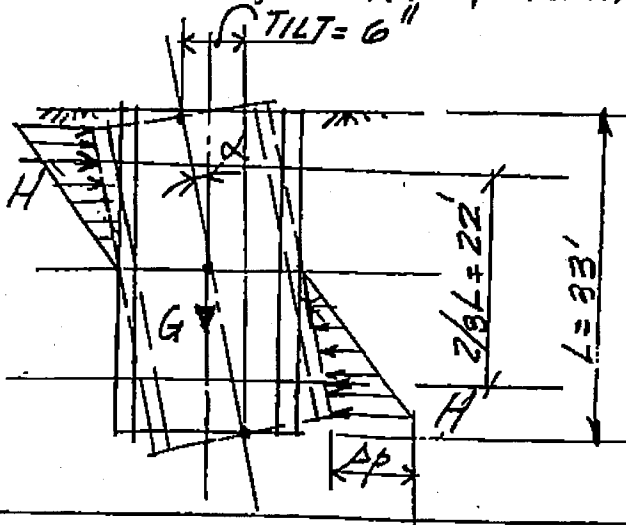
$$T = 0.33 \times 1.0 \times 33' \times 0.150 = 1.69 \text{ k/ft}$$

$$T_u = 1.67 \times 1.4 \times 1.69 = 3.97 \text{ k/ft}$$

$$A_{3c} = \frac{3.97}{0.9 \times 60} = 0.074 \text{ in}^2/\text{ft}$$

Tilting Stresses:

Ref: "Art of Tunnelling" K. Szechy, pg. 793-794.



G = wt. of Sinking Caisson

$$= \pi \times 9 \times 33 \times 1.04 \times 0.150 = 146 \text{ k}$$

Consider maximum tilt of 6 inches.

$$\eta = \tan \alpha = \frac{6}{12 \times 33} = 0.01515$$

$$H = \eta G = 2.21 \text{ k}$$

$$M = H \times \frac{2}{3} L = 48.7 \text{ k}$$

$$S_{xx} = \frac{\pi (10^4 - 8^4)}{64 \times 5} = 57.96 \text{ ft}^3$$



CITY OF HOUSTON		3904.00
PROJECT		JOB NO. 0101
Lift Stn - 2 Pumps w/		4
SUBJECT	100. - 300 GPM each	SHEET
NTP	12-8-94	MAN
DESIGNED	DATE	CHECKED
		1-4-95
		DATE

$$f_b = \frac{48.7}{57.96} = 0.84 \text{ ksf} = 6 \text{ psi axial Compression or Tension in walls.}$$

$= 0.84 \text{ k/ft}$

$$T_{max} = 1.69 + 0.84 = 2.53 \text{ k/ft}$$

$$T_{umax} = 1.65(1.69 \times 1.4 + 0.84 \times 1.7) = 6.33 \text{ k/ft}$$

$$\Delta A_{3i} = 6.33 / 60 \times 0.9 = 0.12 \text{ in}^2$$

$$= 0.06 \text{ in}^2/\text{ft ea face.}$$

$$\Sigma A_3 = 0.38 + 0.06 = 0.44 \text{ in}^2/\text{ft} \quad \#6 @ 12" \text{ V.E.F.}$$

$$= 0.78 + 0.06 = 0.84 \text{ in}^2/\text{ft} \quad \#6 @ 6" \text{ V.O.F. at bottom 3rd of caisson.}$$

$$H = 2.21 \text{ k} = \Delta p h / 4$$

$$\Delta p = \frac{2.21 \times 4}{33} = 0.268 \text{ ksf or } 268 \text{ psf}$$

$$P_{at \text{ base}} = 3250 + 268 = 3518 \text{ psf (8.2\% higher)}$$

$$P_{top} = 100 + 268 = 368 \text{ psf}$$

Bending due to $\Delta p = 268 \text{ psf}$.

Ref: "Stress Coeff. for large horizontal pipes," James M. Paris, ENR Nov. 1921.

Case VIII:

$$M_A = 0.337 \times 0.268 \times 5^2 = 2.26 \text{ k/ft}$$

Horizontal Reinf. $M_u = 1.3 \times 1.7 \times 2.26 = 5.0 \text{ k/ft}$

$$P_{min} = 0.0033$$

$$A_s = 0.44 \text{ in}^2 - \#5 @ 12" \text{ Horiz. EA Face.}$$

$$d = 12.5 - 2.5 - 1 = 11"$$

$$F = 0.121$$

$$K_m = 41. \quad P_{min} = 0.0013 \times 1.33 = 0.0018$$

$$A_s = 0.24 \text{ in}^2/\text{ft}$$



PROJECT		CITY OF Houston		3904-00	
SUBJECT		Lift Sta; 2 pumps 100-300 GPM/pump		JOB NO. 01d	
DESIGNED		NMP		SHEET 5	
DATE		12-8-94		CHECKED	
		R.A.D.		DATE	
				1-4-95	

Resistance to Buoyancy:

Consider total depth = 33' 0"

Top slab 24" = $\frac{\pi \times 10.08^2}{4} \times 2.0 \times 0.150 = 23.94 k$

Base slab 24" = 23.94

walls: $\pi \times 9.04 \times 1.04 \times 29 \times 0.150 = 128.48$

(28' height) $W_{DL} = 176.36 k$

Uplift force: consider flood up to π /top slab

$P = \frac{\pi \times 10.08^2}{4} \times \frac{33 \times 62.4}{1000} = 164.32 k$

Factor of Safety against floatation = $\frac{176.36}{164.32} = 1.07$

$\Delta W = 1.40 \times 164.32 - 176.36 = 53.69 k$

or $\bar{p} = \frac{53690}{\pi \times 10.08 \times 33} = 51 \text{ psf}$

1.4 Min. reqd.

NOTE:

Design consultant to verify with geotechnical consultant value of adhesion and/or friction between caisson wall and soils. Pressure grouting can restore 50 psf and larger adhesion/friction.

Base Slab:

Uplift pressure = $62.4 \times 33 = 2.06 \text{ ksf.}$

Total uplift = $2.06 \times \frac{\pi \times 8^2}{4} = 103.5 k$

peripheral shear = 4.12 k/ft

$M_r = M_t = \frac{103.5}{16\pi} (3 + 0.2) = 6.6 k$ ← orthogonal steel.

$M_u = 1.67 \times 1.7 \times 6.6 = 18.7 k/ft \times 1.41 = 26.4 k$

$d = 18 - 3 - 1 = 14"$ $F = 0.196$ $K_m = 135$ $P = 0.0033$ $A_s = 0.55 \text{ in}^2$

OK BY INDEPENDENT CHK. ALSO

F017 R.H. FW and # 7012 T.E.W.



PROJECT		City of Houston		3904-00	
SUBJECT		Lift Station: 2 Pumps		JOB NO. 0101	
DESIGNED		12-12-94		6	
CHECKED		A. O. N.		SHEET	
DATE		1-3-95		DATE	

Top Slab:

Design loads: LL = 300 psf
or H-20 Truck loading.

DL: 24" conc. slab = 300 psf (w/o beams)

$f'_c = 4000 \text{ psi}$, $f_y = 60,000 \text{ psi}$

Well = 8'-0" diameter

$l = 8'$ max.

$M_{DL} = 0.3 \times 8^2 / 8 = 2.4 \text{ k}$

$M_{LL} = 0.3 \times 8^2 / 8 = 2.4 \text{ k}$ AASHTO LOAD FACTOR: 3.22/1.8

OR $= 0.9 \times 8 \times 1.3 = 9.4 \text{ k}$ $\times 1.3 \times 1.0 = 3.1$
 $(d = 18" - 2 - \frac{1}{2} = 15.5")$ $\times 1.3 \times 1.67 = 20.3 \text{ k/ft}$

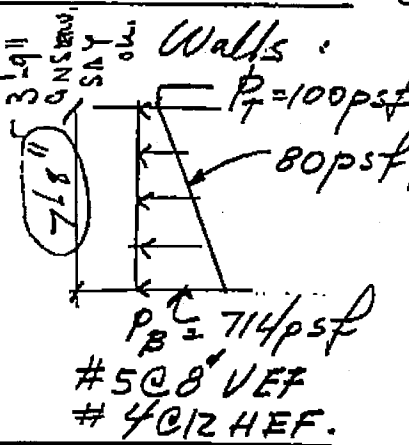
$d = 24" - 2 - \frac{1}{2} = 21.5"$
 $F = 0.462 (0.24)$

$M_u = 1.3 \times 23.4 = 30.4 \text{ k/ft}$ MINES 23.4 k/ft
 $K_n = 66.1 (127.)$
 $\rho_{min} = 0.0033$

$A_s = 0.85 \text{ in}^2 / \text{ft}$ #7 @ 8" Spacing (parallel to long side)
 (0.62 in² / ft) (#6 @ 8" Spacing) of Access opening.
 #5 @ 8" Spacing (transverse)

NOTES: Provide add. bars each side of opening to compensate for interrupted by opening.
 • Provide similar reinf. for Valve Vault's Top Slab.

Valve Vault: Consider flood condition w/ saturated soil



Walls: $K_T / B = 0.14$
 $P_T = 100 \text{ psf}$
 $f = 12"$
 $d = 9.5"$
 $P_B = 714 \text{ psf}$
 $F = 0.090$

$Q = \frac{100 + 714 \times 7.67}{2} = 3.12 \text{ k}$
 $M_{max} = \frac{3.12 \times 7.67}{7.67} = 3.1 \text{ k/ft}$
 $V_T = 0.35 \times 3.12 = 1.12 \text{ k/ft}$
 $V_B = 2.0 \text{ k/ft}$
 $M_u = 1.7 \times 1.3 \times 3.1 = 6.9 \text{ k/ft}$
 $K_n = 77$ $\rho_{min} = 0.0033$
 $A_s = 0.38 \text{ in}^2 / \text{ft}$



PROJECT		CITY OF HOUSTON		JOB NO. 3904-00	
SUBJECT		LIFT STATION - 2 PUMPS		7	
SUBJECT		100-300GPM / Pump		SHEET	
DESIGNED	DATE	CHECKED	DATE		
NMP	12-12-94	ADD	1-3-95		

Value Vault Base Slab:

Loads: Top slab DL = 300 psf
 LL = 300 psf
 OR $2 \times 1.3 \times 16^k / 8.33 \times 7.83 = 638 \text{ psf}$ ✓

CONSERVATIVE IMPACT $[3'-9" - 2'-5" = 1'-10"]$
 Walls: $6.67 (5.83 + 2 \times 8.33) \times 1.0 \times 0.15 = 34.5 \text{ psf}$
 (22.5 k)

$W_u = (1.4 \times 645 + 1.7 \times 638) = 1.99 \text{ ksf}$
 (No sanitary factor = 1.3 used).

$M_u = 1.99 \times 6.83^2 / 8 = 11.6 \text{ k/ft}$ $K_n = 59$

OR $A/B = 6.83 / 8.33 = 0.82$

$M_A = 0.056 \times 1.99 \times 6.83^2 = 5.2 \text{ k/ft}$ $K_n = 27$

$M_B = 0.023 \times 1.99 \times 8.33^2 = 3.2 \text{ k/ft}$

REF. ACI 318-63 METHOD 3 TABLE 2 CASE 1

$d = 18 - 3 - 1 = 14"$ $f = 0.196$ $p_{min} = 0.0033$
 $A_s = 0.55 \text{ in}^2/\text{ft}$
 #6 @ 8" TOP EW.
 #5 @ 12" BOT EW.

Consider Base slab as cantilever from wetwell
 $L = 7.33'$

$M_u = 1.99 \times 7.33^2 / 2 = 53.5 \text{ k/ft}$
 $K_n = 272$ $f = 0.0053$ $A_s = 0.89 \text{ in}^2$ #6 @ 6" Top
 SAY CONSERV. - MOM. TRANSFER TO WALL. OR #7 @ 8" Top ✓
 #8 @ 12" Top

Value Vault Buoyancy check; CONSERVATIVE OR

Zlift: $7.83 \times 8.33 \times (10.17 \times 62.4) / 1000 = 41.4 \text{ k}$ ↑

DL: Top slab $(7.83 \times 8.33 - 5 \times 5) \times 2 \times 0.150 = 12.0 \text{ k}$

Base slab: $7.83 \times 8.33 \times 1.5 \times 0.150 = 14.7$

Walls: $(5.83 + 2 \times 8.33) \times 6.67 \times 1.0 \times 0.150 = 22.5$

F.S. against floatation = $\frac{49.2}{41.4} = 1.20$ 49.2 k ↓

Note: For extension and soil on fl. in'll ...



CITY OF HOUSTON		3904-00
PROJECT	LIFT STATION - 2 PUMPS	JOB NO. 0101
SUBJECT	100 - 300 GPM / PUMP	8
NMP	12-14-94	DAW
DESIGNED	DATE	CHECKED
		1-9-95
		DATE

Valve Support Pad: (No Vault):

Consider ave. length of Cantilever = 8.33'

Loads: 12" conc. slab = 150 psf
OR 4. H-20 Truck loading = 300 psf

(during construction only)

$$M = 0.150 \times 8.33^2 / 2 = 5.20 \text{ k/ft} \times 1.4 = 7.3 \text{ k}$$

$$= 0.300 \times 8.33^2 / 2 = 10.4 \text{ k/ft} \times 1.7 = 17.7 \text{ k} \quad \left. \begin{matrix} \\ \end{matrix} \right\} 25 \text{ k}$$

$$\text{OR } 2 \times 1.30 \times 16 \times \frac{7.33}{7.25} = 42.1 \text{ k/ft} \times 1.7 = 71.4$$

$$d = 12'' - 2 - \frac{1}{2} = 9.5''$$

$$F = 0.09$$

$$A_{s, req} = 0.37 \text{ in}^2$$

#5 @ 8" (TYP)

No truck Allowed.

$$M_u = 25.0 \text{ k/ft}$$

$$K_n = 278 \quad \rho = 0.0054$$

$$A_s = 0.61 \text{ in}^2$$

#5 @ 6 Top D/w/s
from Wetwell
Top slab.

Thrust blocks:

Assume 8" ϕ pipe w/ 50 psi pressure

$$T = \frac{\pi \times 8^2}{4} \times 50 = 2512 \text{ lb} \approx 3 \text{ k}$$

$$M = 3.00 \times 3.50 \text{ above floor} = 10.5 \text{ k}$$

$$M_u = 1.7 \times 10.5 = 17.9 \text{ k}$$

$$V_u = 1.7 \times 3 = 5.1 \text{ k} < \phi V_c = 0.85 \times 2 \sqrt{f'_{c, max}} \times 12 \times 9.5 = 12.3 \text{ k}$$

$$b_t = 12 \times 12'' \quad d = 9.5'' \quad F = 0.09$$

$$K_n = 199 \quad \rho = 0.0039$$

$$A_s = 0.44 \text{ in}^2 \quad \underline{2 \#5}$$



CITY OF HOUSTON		3904-00	
PROJECT		JOB NO 0101	
LIFT STN - 2 Pumps		9	
SUBJECT 100-300 GPM/PUMP		SHEET	
NMP DESIGNED	12-19-94	DATE	1-4-95
		CHECKED	DATE

Assume 20" φ Pipe w/ 50 psi pressure @ 42" above floor

$$T = \frac{\pi \times 20^2 \times 50}{4 \times 1000} = 15.7 k$$

$$V_u = 1.7 \times 15.7 = 26.7 k$$

$$M_u = 15.7 \times 3.5 \times 1.7 = 93.4 k$$

$$\phi V_c = 0.85 \times 2 \sqrt{4000} \times 20 \times 17.5 = 37.6 k$$

$$b_t = 20" \times 20" \quad d = 20" - 2 \times \frac{1}{2}" = 17.5" \quad F = 0.1508$$

$$K_m = 784 \quad \rho = 0.0035$$

$$A_s = 1.22 in^2 \quad 3\#6 \quad \text{or } \phi\#5$$

12" φ pipe w/ 50 psi pressure @ 42" off the floor

$$T = 6 k$$

$$M_u = 6 \times 3.5 \times 1.7 = 35.7 k$$

$$V_u = 6 \times 1.7 = 10.2 k < \phi V_c = 12.3 k$$

$$b_t = 12" \times 12" \quad d = 9 \frac{1}{2}" \quad F = 0.09$$

$$K_m = 397 \quad \rho = 0.0079$$

$$A_s = 0.90 in^2 \quad 3\#5$$

Base slab: 8" φ $M_u = 17.9 k$ $M_u = 5.0 k/ft$
 12" φ $M_u = 35.7$ $\frac{3.58}{1} = 10.0$
 20" φ $M_u = 93.4$ $= 26.0 k/ft$
 $d = 10" - 2 \times \frac{1}{2}" = 7.5" \quad F = 0.056$

8" φ	$K_m = 89$	$\rho = 0.002$	$A_s = 0.18 in^2$	$< \text{Provide } \#5 @ 8" T (min) (0.46)$
12" φ	$K_m = 179$	$\rho = 0.0035$	$A_s = 0.32$	$< \#5 @ 8" T (0.46)$
20" φ	$K_m = 784$	$\rho = 0.0093$	$A_s = 0.84$	$< \#5 @ 8" T Add'l (0.92)$



Houston, Tx Stds		3921-00	
PROJECT LP-SSC Pump STN-C2		JOB NO. 0101	
SUBJECT 2 Pumps @ 250-500 GPM		1 of 3	
SUBJECT Low Profile - secured		SHEET	
DESIGNED NMP	DATE 11-29-95	CHECKED	DATE

VALVE VAULT: 12' x 12'-2" x 8'-8" Walls t = 12"

Grating - FRP = 25 psf
 LIVE LOAD = 150 psf
 W = 175 psf

GRATING SUPP. BEAM:

L = 10'-2"
 $W = 175 \left(\frac{3.17 + 2.92}{2} \right) = 533 \text{ plf}$
 Beam Wt = 42
 575 plf

$M = 0.575 \times 10.17^2 / 8 = 7.4 \text{ k}$
 $V = 0.575 \times 10.17 / 2 = 2.92 \text{ k}$
 W8X15 $I_u = 10.17'$
 $M_R = 15.1 \text{ k}$

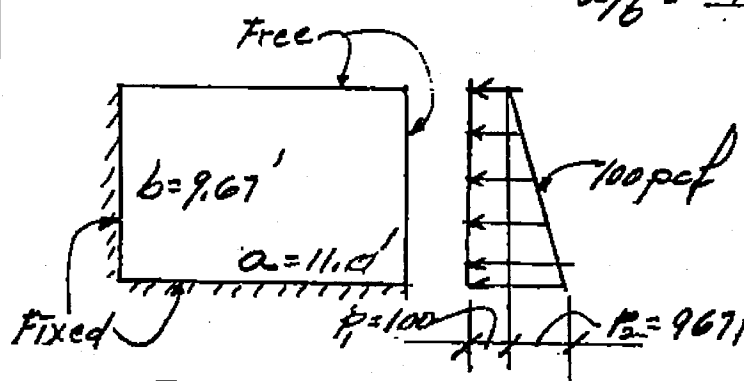
Provide single plate shear connection
 3/8" PL x 6" x 6" w/ 2-3/4" x 1 1/2" Horiz slotted holes
 for 2-3/4" DIA A325 Bolts.

$V_{allow} = 8.2 \text{ k} > V = 2.92 \text{ k}$

Wall face PL 3/8" x 6" x 8" w/ 2-3/4" x 6" lg Studs.

PIT WALLS:

$a/b = \frac{11.0'}{9.67} = 1.14 \approx 1.00$



$P_1 b = 11$
 $P_1 b^2 = 9.4$
 $P_2 b = 9.4$
 $P_2 b^2 = 90.4$

$M_x^- = 0.2949 \times 9.4 + 0.0662 \times 90.4 = 8.8 \text{ k}$
 $M_x^+ = 0.0324 \times 9.4 + 0.0077 \times 90.4 = 1.0 \text{ k}$
 $M_y^- = 0.2949 \times 9.4 + 0.1157 \times 90.4 = 13.2 \text{ k}$
 $M_y^+ = 0.0324 \times 9.4 + 0.0172 \times 90.4 = 1.9 \text{ k}$

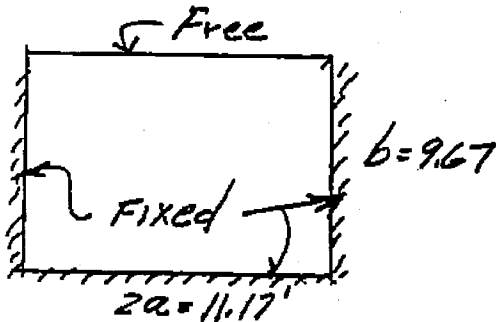
$M_{ux}^- = 14.9 \text{ k/ft}$
 $= 1.7 \text{ k/ft}$
 $= 22.5 \text{ k/ft}$
 $= 3.2 \text{ k/ft}$



Houston, Tx Stds.		3921-00	
PROJECT		JOB NO 0101	
2 Pumps @ 250-500 GPM EA.		2 OF 3	
SUBJECT Secured site		SHEET	
UMP	11-30-95	CHECKED	DATE
DESIGNED			

$t = 12''$ $d_v = 12'' - 2 - \frac{1}{2} = 9.5''$ $F = 0.093$
 $d_H = 12 - 3 - \frac{1}{2} = 8.5''$ $F = 0.072$

$K_{MH}^- = 207$	$\rho = 0.0040$	$A_{3H}^- = 0.54 \text{ in}^2/\text{ft}$	#5 @ 12" O.C. CORNERS
$K_{MH}^+ = 24$	$\rho = 0.0073$	$A_{3H}^+ = 0.18 \text{ in}^2/\text{ft}$	#4 @ 12" VEF.
$K_{MV}^- = 242$	$\rho = 0.0047$	$A_{3V}^- = 0.71 \text{ in}^2/\text{ft}$	#5 @ 6" DWLS OF #5 @ 12" IF.
$K_{MV}^+ = 34$	$\rho_{min} = 0.0013$	$A_{3V}^+ = 0.20 \text{ in}^2/\text{ft}$	#4 @ 12" VEF.



$a/b = \frac{11.17}{2 \times 9.67} = 0.58$

$M_x^- = 0.8592 \times 9.4 + 0.0406 \times 90.4 = 11.7 \text{ k-ft}$	$M_u = 20 \text{ k-ft}$		
$M_x^+ = 0.0807 \times 9.4 + 0.0214 \times 90.4 = 2.7$	= 4.6		
$M_y^- = 0.1212 \times 9.4 + 0.0584 \times 90.4 = 6.4$	= 10.9		
$M_y^+ = 0.0245 \times 9.4 + 0.0139 \times 90.4 = 1.5$	= 2.5 k-ft		
$K_{MH}^- = 278$	$\rho = 0.0054$	$A_{3H}^- = 0.73 \text{ in}^2$	#5 @ 8" O.C. CORNERS
$K_{MH}^+ = 63$	$\rho = 0.0013$	$A_{3H}^+ = 0.18$	#4 @ 12" VEF.
$K_{MV}^- = 117$	$\rho = 0.0023$	$A_{3V}^- = 0.35$	#5 @ 6" DWLS OF #5 @ 12" DWLS IF.
$K_{MV}^+ = 27$	$\rho = 0.0013$	= 0.20	#4 @ 12" VEF.

BASE SLAB

Dead Loads: 12" walls $2 \times 11.5 \times 8.67 \times 0.150 = 29.9 \text{ k}$

$1 \times 10.17 \times 8.67 \times 0.150 = 13.2$

16" Base slab = $11.5 \times 12.17 \times 1.33 \times 0.150 = 27.9$

Soil wt: $(2 \times 12.5 + 12.17) \times 10.0 \times 2.06 = 22.3$

2 plift = $11.5 \times 12.17 \times 10.0 \times 0.062 = 87.3 \text{ k}$ $\frac{93.3 \text{ k} \downarrow}{87.3 \text{ k} \uparrow}$

Factor of Safety against flotation = $\frac{93.3}{87.3} = 1.07 < 1.25$



Houston, Tx Stals		3921-00
PROJECT		JOB NO. 0121
2 Pumps - 250-500 GPM		3 of 3
SUBJECT	Secured Site Pump Stn.	SHEET
NMP	11-30-95	
DESIGNED	DATE	CHECKED
		DATE

Resisting Force required = $1.25 \times 87.3 - 93.3$
 $= 15.8 k$

Shear Transfer to Wet well will provide; $\frac{15.8}{2} = 7.9 k / 10' - 11'$

NOTE: see sht. 2 of 4 of 3-pumps, 250-2000 GPM EA.

Secured Site Pump Stn. Calcs.
For wall bracket and dowel bar designs.

BASE SLAB:

$L = 11.17'$
 net uplift = $0.062 \times 10' = 0.624 ksf$ $\times 1.7 = 1.061$
 16" slab = $0.200 u$ $\times 1.4 = 0.280$
 $0.424 pcf \uparrow$ 0.781

$M_u = 0.781 \times \frac{11.17^2}{8} \times 1.3 = 15.8 k/ft$

$V_u = 0.781 \times (\frac{11.17}{2} - 1.5) = 3.19 k/ft$ $(2 \times 0.85 \sqrt{4000} \times 12 \times 12.5)$
 $= 16.1 k = \phi V_c$

$t = 16''$ $d = 16 - 3 - \frac{1}{2} = 12.5''$ $F = 0.156$

$K_m = 101$ $\rho = 0.002$ $A_s = 0.40 in^2/ft$
#5 @ 8" EW and
#5 @ 12" Bot EW.



CITY OF HOUSTON, TX		3904-00	
PROJECT		JOB NO. 0101	
STD. PUMP STN - 2 PUMP.		1	
SUBJECT 250 - 500 GPM EA.		SHEET	
NMP	10-25-94	JAM	11-4-94
DESIGNED	DATE	CHECKED	DATE

DESIGN CRITERIA :

(Sht. C2)

Design Grade Floor:

Live Load:

H-20 Truck Loading OR

Max. Pump Wt. = 5000 lbs. OR 2/0L = 300 psf.

Dead Load:

Consider 24" slab w/o Beams. Simple and Cost-effective.

24" Conc. = 300 psf

$f_c = 4000 \text{ psi}$, $f_y = 60,000 \text{ psi}$

WET WELL:

$$l = 2 \times \sqrt{5.50^2 - 1.38^2} = 10.65 \text{ ft}$$

$$w_{DL} = 300 \text{ psf}$$

$$w_{LL} = 300 \text{ psf}$$

H-20 Truck

(AASHTO, 3.22.1A)
Table factors

$$L_u = 12.65 \text{ ft } \frac{1}{8}$$

$$M_{DL} = 0.3 \times 12.65^2 / 8 = 6.9 \text{ k/ft}$$

$$M_{LL} = 6.0 \text{ k/ft}$$

$$M_{LL1} = 0.9 \times 12.65 \times 1.3 = 14.8 \text{ k/ft}$$

$$M_{LL2} = \frac{(12.65 + 2) \times 16 \times 1.3}{32} = 9.5 \text{ k/ft}$$

$$M_{u,des} = (7.8 + 32.1) \times 1.3 = 51.9 \text{ k/ft}$$

$$M_{DLu} = 1.3 \times 1.6 \times 6.0 = 7.8 \text{ k/ft}$$

$$M_{LLu} = 1.3 \times 1.67 \times 14.8 = 32.1 \text{ k/ft}$$

$$K_m = 112$$

$$\rho = 0.0021$$

$$\rho_{min} = 0.0033 \checkmark$$

$$A_s = 0.85 \text{ in}^2$$

#6 @ 6" Bottom (0.88 in²/ft)

2/5e → #7 @ 8" Bott. (Parallel to Long side of Opng)

#5 @ 8" Bott & Top (Transverse direction)

NOTE: Provide Addl bars equal to 1/2 Interrupted by opng on ea. side of opng (Struct. Std.)

VALVE VAULT:

Top Slab:

$$l = 11.17'$$

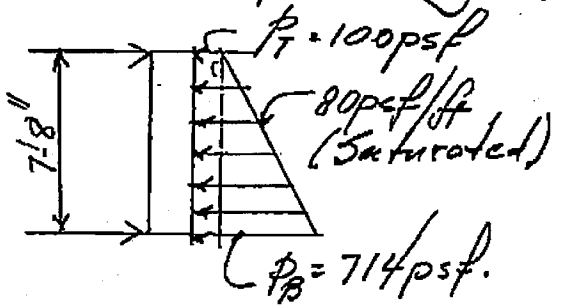
Use same reinf as wetwell Top Slab.



PROJECT		CITY OF HOUSTON, TX	3904-00-
SUBJECT		STD. PS - 2 Pumps	JOB NO. 0101
DESIGNED		NMP	2
DATE		10-25-94	SHEET
CHECKED		JAM	11-4-94
DATE			

VALVE VAULT WALLS:

Consider flood condition with soil saturated to full height, equivalent lat. pressure of 80psf.



Wall Vert span = 6'-8"
Wall thick. = 1'-0"
7'-8"

$p_T/p_B = 0.14$
 $Q = \frac{100 + 714}{2} \times 7.67' = 3.12k$

$M_{max} = \frac{3.12 \times 7.67}{7.82} = 3.1 \text{ k/ft}$

$V_T = 0.35 \times 3.12 = 1.12k$

$V_B = 0.65 \times 3.12 = 2.0k$

$M_u = 1.7 \times 1.30 \times 3.1 = 6.9 \text{ k/ft}$

$d = 12" - 2" - \frac{1}{2}" = 9.5", F = 0.090$

$K_m = 76$

$\rho = 0.0014$
 $\rho_{min} = 0.0033 \leftarrow 2/se$

$A_s = 0.38 \text{ in}^2/\text{ft}$

#5 @ 8" Vert EF.
#4 @ 12" Hor. EF.

VALVE VAULT BASE SLAB:

Loads: Top Slab

$A = 11'-2"$
 $B = 12'-10\frac{1}{2}" (\pm)$
 $m = 0.87$
 $= 300 \text{ psf}$

35.92k

Walls $(10.17' + 2 \times 12.87') \times 0.150 \times 6.67' = 197 \text{ k}$
 $13.17' \times 13.87'$

LL: $2 \times 20.8 / 13.17 \times 13.87 = 227 \text{ psf}$
OR
 $= 300 \text{ psf}$

$M = 0.797 \times 11.17^2 / 8 = 12.4 \text{ k/ft}$, $M_u = 24.2 \text{ k/ft}$

OR $M_A = 0.050 \times 0.797 \times 11.17^2 = 5.0 \text{ k/ft}$, $M_u = 1.3 \times 1.5 \times 5.7 = 9.8 \text{ k/ft}$

$M_B = 0.026 \times 0.797 \times 12.87^2 = 3.4 \text{ k/ft}$, $K_u = 68$, $\rho = 0.0013$

$d = 16 - 3 - 1 = 12"$, $F = 0.144$
2/se $\rightarrow \rho_{min} = 0.0033$, $A_s = 0.48$
#5 @ 8" TOP EW-7 $t = 16"$
#5 @ 12" BOT EW-5



CITY OF HOUSTON, TX.		3904.00-	
PROJECT	STD. PS. - 2 PUMPS 250-500 GPM.		3
SUBJECT	WITHOUT VAULT		SHEET
NIMP DESIGNED	10-26-94	JAM CHECKED	11-4-94
DATE		DATE	

VALVE PAD:

(Sht. 44)

Consider average length of Cantilever = 8'-8"

Loads: 10" conc. slab = 125 psf x 1.4 = 175
 LL (No Truck) - (possible) = 150 psf x 1.7 = 255

$M = 0.28 \times 8.67^2 / 2 = 10.5 \text{ k/ft} \times 1.56 = 16.4 \text{ k/ft} = M_u$

$V = 0.28 \times 8.67 = 2.43 \text{ k/ft} = 3.8 \text{ k/ft} = V_u$

$d_7 = 10" - 2" - 1" = 7.0" \quad F = 0.049$

$d_8 = 10 - 3 - 1/2 = 6.50" \quad K_n = 335 \quad \rho = 0.0067$

$F = 0.0423$

$A_g = 0.56 \text{ in}^2/\text{ft}$ #5 @ 8" Top Cont
 #5 @ 12" Top Add.
 ($A_g = 0.73 \text{ in}^2/\text{ft}$)
 OR #5 @ 6" d w/s.

NOTE: All other details same as before.

Alt: $A = 7'-8"$ $B = 8'-2"$ $m = 0.94$ ACI-Method-3 (68).

$M_A = 0.040 \times 275 \times 7.67^2 = 0.65 \text{ k/ft}$

$M_B = 0.033 \times 275 \times 8.17^2 = 0.61 \text{ k/ft}$

Provide #5 @ 12" T & B EW (min).

$V_A = 0.55/2 \times 0.275 \times 7.67 = 0.58 \text{ k/ft}$

$V_B = 0.45/2 \times 0.275 \times 8.17 = 0.51 \text{ k/ft}$

Provide 1'-0" width at bottom of Gr. Wall -

check Bouyancy of Vault:

$h_w = \frac{2.0 \text{ Top slab} + 6.67 \text{ Walls} + 1.50 \text{ Base slab}}{10.17}$

$h_w = 10.17$

$2 \text{ uplift} = 62.4 \times 10.17 = 635 \text{ psf} \uparrow$

$\Sigma DL = 24" \text{ Top slab} = 300 \text{ psf}$
 $12 \text{ walls} = 197 "$
 $18" \text{ Base} = 225 "$
 $\text{soil} = 60 "$
 $F.S. = \frac{782}{635} = 1.23$



Houston, Tx 5tds		3921-00
PROJECT LP-SSC PUMP STN. D2		JOB NO. 0101
3 Pumps @ 250-2000 GPM		1 of 4
SUBJECT Low Profile - Secured		SHEET
NMP DESIGNED	11-10-95	CHECKED
		DATE

Valve Vault: 15'-0" x 20'-3" x 8'-8" Walls t=12"

Grating: FRP = 25 psf
 LL = 150 "
 175 psf

Beam: L = 18'-3"
 W = 175 psf x (4.33 + 3.17) = 656 plf
 Bm wt say = 44
 700 plf

M = 0.7 x 18.25^2 / 8 = 29.1 k

W = 12.78 k V = 6.39 k W8X24 MR = 31 k
 Lu = 18.25'

Delta approx = 1.00 x 12.78 / 18 = 0.71" = L / 308 ✓

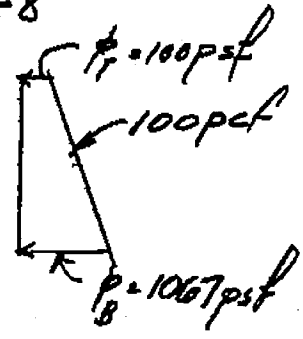
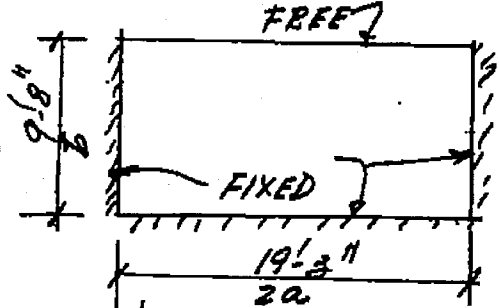
Single-plate Shear Connection, Table X-A pg 4-34
 3/8" PL x 6" x 6" w/ 13/16 x 1 1/2" Long (Hole) Slotted
 Holes for 2- 3/4" phi R325 Bolts.

Vallow = 8.2 k > V = 6.39 k

Wall face t = 3/8" x 8" w/ 2- 3/4" phi x 6" Long Studs.

Pit Walls: Ref: BOR, EM. NO. 27

End Panel = 19'-3" x 9'-8"



a/b = 19.25 / (2 x 9.67) = 1.00
 p1 b^2 = 9.35
 p2 b^2 = 0.97
 p1' b^2 = 0.967 x 9.67^2 = 90.4
 p2' b^2 = 0.967 x 9.67^2 = 9.35

Mx+ = 0.1 x 9.35 + 0.0276 x 90.4 = 3.43 k/ft Mu = 5.8 k/ft
 Mx- = 0.2613 x 9.35 + 0.0644 x 90.4 = 8.26 = 14.0
 Mz = 0.2043 x 9.35 + 0.1845 x 90.4 = 9.55 k/ft = 16.2 k/ft



Houston Tx - Stds.		3921-00
PROJECT		JOB NO. 0/0/
3 Pump Sta - Valve Vault		2 of 4
SUBJECT		SHEET
NTP	11-13-95	
DESIGNED	DATE	CHECKED
		DATE

$M_y^+ = 0.0243 \times 9.35 + 0.0159 \times 90.4 = 1.7^k$ $M_{uc} = 2.9^k$

$d_v = 12 - 2 - \frac{1}{2} = 9.5''$ $F_v = 0.09$
 $d_H = 12 - 3 - \frac{1}{2} = 8.5''$ $F_H = 0.07$

$K_H^- = 200.$	$P_H^- = 0.0039$	$A_{3H}^- = 0.40 \text{ in}^2/\text{ft}$	#5 @ 12" OF
$K_H^+ = 83.$	$P_H^+ = 0.0016$	$A_{3H}^+ = 0.33 \text{ in}^2/\text{ft}$	#5 @ 12" OF @ Col
$K_v^- = 180.$	$P_v^- = 0.0034$	$A_{3v}^- = 0.39$	#5 @ 12" V OF
$K_v^+ = 32.$	$P_v^+ = 0.0013$	$A_{3v}^+ = 0.37$	#5 @ 6" V OF DRILLS #5 @ 12" V IF

Base Slab:

Loads: DL = 1' walls $2 \times 8.67' \times 14.50' \times 0.150 = 37.7^k \downarrow$
 16" Base slab = $20.25' \times 15' \times 1.33' \times 0.150 = 60.6^k \downarrow$
 1' wall $1 \times 19.25' \times 8.67' \times 0.150 = 25.0$
 $123.3^k \downarrow$

Up lift = $15' \times 20.25' \times 9' \times 0.062 = 170.6^k \uparrow$

Try 16" wide projection of Base slab.

Soil wt = $0.06 \times 1' \times 9' (18.25 + 2 \times 15.50) = 40.9^k \downarrow$

$\Delta W_{DL} \text{ req'd} = (1.25 \times 170.6 - 123.3 - 40.9) = 49.6^k \downarrow$

Consider this provided by Shear transfer thru side wall to wet well:

$V = 24.5^k / \text{wall}$. #7 @ 12" dwls = 8 #7 dwls.

$A_b = 0.60 \text{ in}^2$

$\phi V_c = 0.85 \times 800 \times 0.6 \sqrt{4000} = 25804 \#$

OR $= 0.85 \times 2 \pi \times 6^2 \sqrt{4000} = 12160 \#$

$V_u = 24.5 \times 1.7 = 41.65^k < 8 \#7 = 12.16 \times 8 = 97.28^k$

$\phi V_c = 0.85 \times 2 \sqrt{4000} \times 12 \times 96 = 123.86^k \gg V_u = 41.65^k$



Houston Tx Sds		3921-00
PROJECT		JOB NO. 0101
3 Pumps - 250 - 2000 GPM		3 of 4
SUBJECT		SHEET
NMP	11-13-95	
DESIGNED	DATE	CHECKED
		DATE

Bracket from wet well wall:

Consider 5' wide base slab and 5'-0" of walls from Vault supported on to bracket.

$$P_{slab} = 1'-6" \text{ slab @ } 225 \text{ psf} \times 5' = 1125 \text{ \#/ft}$$

$$LL @ 150 \text{ psf} \times 5' = 750$$

$$P = 1875 \text{ \#/ft}$$

$$P_{wall} = 0.150 \times 8.67' \times 5' = 6.50 \text{ k}$$

$$W = 2'-6" \text{ slab} = 375 \text{ psf}$$

Assume wet well wall $t = 2'$

$$L_{min} = 1'-0"$$

$$L_{max} = (10.25' - 10.25 \cos 45^\circ) + 1.00' = 4.00'$$

$$L_{ave} = 2.5'$$

$$M_{ave} = 0.375 \times 2.5^2 / 2 = 2.3 \text{ k/ft}$$

$$1.875 \times 2.5 = 4.7$$

$$7.0 \text{ k/ft}$$

$$M_{max} = 0.375 \times 4^2 / 2 = 3.0$$

$$1.88 \times 4 = 7.52$$

$$10.52 \text{ k/ft} \times 1.7 = 17.9 \text{ k/ft}$$

$$d = 18 - 2 - 1 = 15"$$

$$F = 0.225$$

$$K_m = 80$$

$$P_{min} = 0.002$$

$$A_s = 0.32 \text{ in}^2 / \text{ft}$$

$$\#6 @ 12 (0.44)$$

Provide

Wall as bracket: $L = 4.60'$

$$P = 6.5 \text{ k}, W = 1.3 \text{ k/ft}$$

$$M = 6.5 \times 4.6' = 30.0 \text{ k}$$

$$1.3 \times 4.6^2 / 2 = 14.0$$

$$44.0 \text{ k}$$

$$\text{OR } P_{\text{lift}} = 24.5 \text{ k}$$

$$M_{\text{lift}} = 24.5 \times 4.6 = 113 \text{ k}$$



Houston, TX Stds.		3921-00
PROJECT		JOB NO. 1010
3 Pumps - 250-2000 GPM		4 of 4
SUBJECT		SHEET
NMP	11-14-95	
DESIGNED	DATE	CHECKED
		DATE

Ref: PCA - "Simplified Design" Shear Walls, pg. 6-13

$M_{u1} = 1.4 \times 44 = 62 \text{ k-ft}$

$M_{u2} = 1.7 \times 113 = 192 \text{ k-ft} \leftarrow \text{Controls}$

$\phi M_n = \phi \left[0.5 A_s f_y l_w \left(1 + \frac{P_u}{A_s f_y} \right) \left(1 - \frac{e}{l_w} \right) \right]$

$\frac{e}{l_w} = \frac{w}{2w + 0.85 \beta_1} \quad \beta_1 = 0.85 \text{ for } f_c = 4000$
 $= \frac{0.085}{0.17 + 0.72} = 0.095$

$\phi M_n = 0.90 \left[0.5 \times 7.04 \times 60 \times 104 \times 0.905 \right]$

Base 5/6: $= \frac{12}{12} = 1490 \text{ k} >> 192 \text{ k}$

$l = 19.3 \text{ ft}$

$W_{\text{uplift}} = 9 \times 0.062 - 1.33 \times 0.15 = 0.362 \text{ k-ft} \uparrow$

$M = 0.362 \times 19.25 \times \frac{2}{3} = 16.8 \text{ k-ft} \times 1.7 \times 1.3 = 37.1 \text{ k-ft} = M_u$

$V = 0.362 \times 19.25 \times \frac{1}{2} = 3.48 \text{ k-ft} = 7.7 \text{ k-ft} = V_u$

$t = 16 \text{ in (min)} \cdot d = 16 - 2 - \frac{t}{2} = 13.5 \text{ in}$

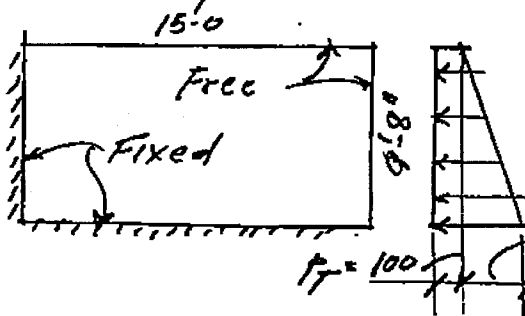
$F = 0.182$

$k_m = 203 \quad \rho = 0.004$

$A_3 = 0.65 \text{ in}^2/\text{ft}$

- #6 @ 8" T in long direct
- #5 @ 8" T in short
- #5 @ 12" BOT EW

Pit Side walls:



$a/b = 15/9.67 = 1.6 > 1.0 \text{ use } 1.0$

$\frac{1}{T} b^2 = 9.35 \quad \frac{1}{T} b = 0.97$

$\frac{1}{B} b^2 = 90.4 \quad \frac{1}{B} b = 9.37$

$M_{\text{cant}} = 0.1 \times 8.67^2 / 2 = 3.8 \text{ k-ft}$

$0.1 \times 8.67^3 / 6 = 10.9$

$f_T = 100 \times \frac{9.67}{12} = f_B$

$M_u = 25 \text{ k-ft} \quad M_c = 14.7 \text{ k-ft}$

$k_m = 278 \quad \rho = 0.0054$

$A_3 = 0.62 \text{ in}^2/\text{ft}$



CITY OF HOUSTON, TX		3904-00	
PROJECT		JOB NO. 0101	
STD. P.S. - 3 Pumps, 250-2000 GPM EA.		4	
SUBJECT		SHEET	
NMP DESIGNED	10-27-94	JAM CHECKED	11-4-94
DATE		DATE	

WET WELL:

(Sht. C6)

TOP SLAB:

LL: Equipment etc. = 300 psf.
 OR H-20 Truck loading.
 Max pump wt = 5000 lbs
 DL: 24" thick Conc. Slab = 300 psf.

$$L_{max} = 2 \sqrt{-2.15^2 + 8.25^2} = 15.92 + 2.0 = 17.92'$$

$$M_{DL} = 0.300 \times 17.92^2 / 8 = 12.0^{16/ft} \times 1.0 = 12.0^{16/ft}$$

$$M_{LL} = \left(\frac{17.92 + 2}{32} \right) 1.3 \times 16 = 12.9^{16/ft}$$

$$M_{LL} = 0.9 \times 17.92 \times 1.3 = 21.0^{16/ft} \times 1.67 = 35.0^{16/ft}$$

$$M_{DL+LL} = 33.0^{16/ft}$$

$$M_u = 47.0^{16/ft} \times 1.3 = 61.1^{16/ft}$$

$$d = 24 - 2 - \frac{1}{2} = 21.5''$$

$$F = 0.462'$$

$$K_n = 132$$

$$P = 0.0026, P_{min} = 0.0033$$

$$A_3 = 0.85 \text{ in}^2 / \text{ft}$$

$$= 606 \text{ Bott} (0.88)$$

$$\Delta K_n = 72, K_n = 204$$

$$P = 0.0040, A_3 = 1.03 \text{ in}^2 / \text{ft}$$

$$= 808'' (1.19) \text{ Bott.}$$

$$= 508'' \text{ Temp.}$$

Sanitary factor
 NOTE: Additional moment due to opening. $\Delta M = 2.15' \times 12 \times 1.3 = 33.5^{16/ft}$

VALVE VAULT:

TOP SLAB:

$$L = 19.13''$$

$$M_{DL} = 0.300 \times 19.25^2 / 8 = 13.9^{16/ft} \times 1.0 = 13.9^{16/ft}$$

$$M_{LL} = 0.9 \times 19.25 \times 1.3 = 22.5^{16/ft} \times 1.67 = 37.6^{16/ft}$$

Addl. Mom. due to opening.

$$M_u = 51.5^{16/ft}$$

$$\Delta M = 2.0 \times 13.9 = 27.8$$

$$M_{DES} = 13 (51.5 + 27.8) = 103^{16/ft}$$

$$K_n = 223$$

$$P = 0.0043$$

$$A_3 = 1.10 \text{ in}^2$$

$$\#8 \times 8'' \text{ Bottom - } \#5 \times 8'' \text{ Temp. Steel.}$$



CITY OF HOUSTON, TX		3904-02	
PROJECT	STD.P.S. - 3 pumps		JOB NO. 0101
SUBJECT		250-2000 - GPM	5
NMP DESIGNED		10-31-94	JAM
DATE		CHECKED	
		11-4-94	
		DATE	

VALVE VAULT WALLS:

Same as for Pump station - 2 pumps.

BASE Slab:

Loads: Top slab 2" thick = 300 psf 420
 LL = 300 psf use 510
 or $2 \times 20.8 / 20.25 \times 15.0 = 137 \text{ psf}$
 Walls $\frac{(2 \times 150' + 18.42') \times 6.67 \times 0.15}{20.25 \times 15.0} = 160 \text{ psf}$ 224

$W_e = 760 \text{ psf}$ $W_u = 1154 \text{ psf}$
 (1.52).

$A = 13'-8"$
 $B = 19'-3"$ $m = 0.71$

$M_A = 0.068 \times 1.15 \times 13.67^2 = 14.6 \text{ ft-k}$
 $M_B = 0.016 \times 1.15 \times 19.25^2 = 6.8 \text{ ft-k}$

$t = 16"$ $d = 16 - 3 - 1 = 12"$
 $F = 0.144$

$K_{MA} = 101$ $f = 0.002$ $P_{min} = 0.0033$
 $A_{3min} = 0.48 \text{ in}^2$

#5 @ 8" T EW
 #5 @ 12" BOT EW. $t = 16"$ Base Slab.

check Bouyancy of Valve Vault:

$h_w =$ Top slab $t = 2'-0"$ ΣDL : Top slab = 300 psf
 wall ht = 6'-8" Walls = 160 psf
 Base $t = 1'-6"$ Soil (6") = 60"
 Base Slab = 225
 Uplift = 635 psf \uparrow 745 psf

$F.S = \frac{745}{635} = 1.17 \approx 1.20$

Note: May increase base slab projection from 6" to 12" $F.S = 1.27$.



CITY OF HOUSTON, TX		3904.00	
PROJECT		JOB NO. 0101	
STD. P.S. - 3 PUMPS, 250-3000		6	
SUBJECT W/O VAULT. EPMCA		SHEET	
NMP	10-28-94	JAM	11-4-94
DESIGNED	DATE	CHECKED	DATE

VALVE PAD:

Consider two-way slab

(Sht. C9)

A = 10'-4"
 B = 15'-0" m = 0.69

W = 125 psf 175
 150 psf 255
 275 psf 430 psf

$M_A = 0.068 \times 0.43 \times 10.33^2 = 3.1 \text{ k/ft}$
 $M_B = 0.016 \times 0.43 \times 15.0^2 = 1.6 \text{ k/ft}$
 $K_{m1} = 73. P = 0.0014$

d = 10" - 3 - 1/2" = 6 1/2" (1.56)
 $A_{smin} = 0.25 \text{ #5 @ 12"$
 F = 0.423

Provide #5 @ 12 T & Bottom. EW.

$V_A = \frac{0.85}{2} \times 275 \times 10.33 = 1.21 \text{ k/ft}$
 $V_B = \frac{0.15}{2} \times 275 \times 15.00 = 0.31 \text{ k/ft}$

Consider Soil Bearing press = 1500 psf

W = Gr. Floor = 1.21 k/ft
 GR Bm 10" x 20" = 0.22

Width of footing = $\frac{1.43 \text{ k/ft}}{1.50} = 0.95 \text{ ft}$

Provide 10 width at bottom.

Alt: Consider cantilever from wet well =

L = 11.33'
 $W_w = 430 \text{ psf}$
 $M_w = 0.43 \times 11.33^2 / 2 = 27.6 \text{ k/ft}$
 d = 12" slab - 2 - 1/2" = 9.5"
 F = 0.09 $K_m = 307$

P = 0.006
 $A_s = 0.68 \text{ in}^2 / \text{ft}$ #6 @ 8" at Wet well wall.
 or #5 @ 8" + #5 @ 16" A. dd. continuous @ wall.



CITY OF HOUSTON		390400	
PROJECT		JOB NO. 0101	
STD PS. 3 PUMPS. 2000-5300		7	
SUBJECT		SHEET	
GPM/PUMP			
NMP	10-31-94	JAM	11-3-94
DESIGNED	DATE	CHECKED	DATE

WET WELL: TOP SLAB:

(St. C11)

$$l = 7'-3\frac{1}{2}"$$

$$\frac{1'-6"}{8'-9\frac{1}{2}"}$$

$w = 12" \text{ slab} = 150 \text{ psf}$
 $LL \text{ 2D.} = 300 \text{ psf}$

OR H-20 loading:

$M = 0.150 \times 8.8^2 / 8 = 1.45 \text{ k/ft}$
 $0.300 \times 8.8^2 / 8 = 2.90 \text{ k/ft}$

$\times 1.0 \times 1.3 = 1.9 \text{ k}$

Sanitary factor

OR $0.9 \times 8.8 \times 1.3 = 10.3 \text{ k/ft}$

$\times 1.67 \times 1.3 = 22.9 \text{ k}$

$M_u = 24.30 \text{ k/ft}$

$d = 12" - 2" - \frac{1}{2}" = 9.5$

$F = 0.090$

$K_m = 270$

$\rho = 0.0053$

$A_s = 0.62 \text{ in}^2$

#6 @ 8 Bott (Tran)

#5 @ 8 T.E.W

#5 @ 8 Bott (Long.)

Beams:

Loads: DL = w_1 at $\frac{1}{2}$ of span $150 \times 7.3\frac{1}{2} = 0.55 \text{ k/ft}$

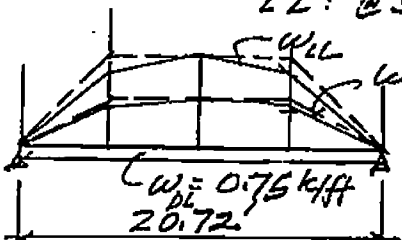
w_2 at $\frac{1}{4}$ point $150 \times 6.0\frac{1}{2} = 0.45$

Bm wt. $1.5 \times 3.0 \times 0.15 = 0.675 = 0.75 \text{ k/ft}$

Hatches @ $30 \text{ psf} \times 2.55' = 0.08$

LL: @ $300 \text{ psf} \times (3.65 + 2.55 + 1.50) = 2.31 \text{ k/ft} = w_1$

$\times (3.0 + 2.55 + 1.50) = 2.12 = w_2$



Consider $w_{DL} = 0.55 \text{ k/ft}$ in mid-half
 $w_{LL} = 2.31 \text{ k/ft}$ in mid-half
 and 0 at support

$w_{DL} = 7.77 \text{ k}$		7.77 k
2.85		2.85
1.43		1.43
<hr/>		<hr/>
11.97	12.05 k	11.97 12.05 k
5.98		5.98
<hr/>		<hr/>
30.0	17.95 k	30.0 k 17.95

$M = 30 \times 10.36 = 310.8 \text{ k}$
 $-7.77 \times 5.18 = -40.2$
 $-1.43 \times 6.90 = -9.9$
 $-2.85 \times 2.59 = -7.4$
 $-11.97 \times 2.59 = -30.9$
 $-5.98 \times 6.90 = -41.3$
 $\frac{181.1 \text{ k}}{57.5}$
 $\frac{72.2}{72.2}$

$V_u = 12.05 \times 1.4 = 16.87$

$17.95 \times 1.7 = 30.53$

$V_{u2} = 47.40 \text{ k (1.58)}$

$M_{u2} = 491 - 1.4 \times 57.5 - 1.7 \times 72.2$

$= 491 - 80.5 - 122.7 = 287.8 \text{ k}$



CITY OF HOUSTON		3904.00
PROJECT		JOB NO. 0101
570 Pump STN. 3 Pumps		8'
SUBJECT	2000-5300 GPM	SHEET
DESIGNED	NMP	11-7-94
DATE	10-31-94	DATE
CHECKED	JAM	

$l_h = 18" \times 30"$ $d = 30 - 3 - 1 = 26"$
 $F = 1.014$
 $K_m = 287.8 / 1.014 = 284$ $P = 0.0055$
 $A_3 = 2.57 \text{ in}^2$ 4 #8 Both
 $\phi V_c = 18 \times 26 \times 2 \sqrt{4000} \times 0.85$ 2 #7 Top Cont.
 $= 50.32 \text{ k} > V_u = 47.4 \text{ k}$ #4 @ 12" thru out.

VALUE VAULT:

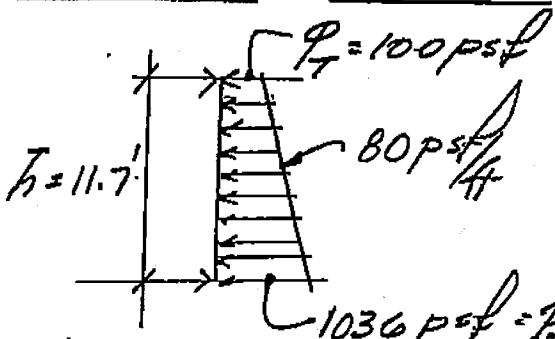
TOP SLAB:
 $l = 7'6"$ $w = 12" \text{ slab}$ $= 150 \text{ psf}$ 300 psf $24"$
 $\frac{126"}{9'0"} = 14$ $LL: 2/DL = 300$ $d = 21"$
 $OK H-20 Loading.$ $F = 0.441$
 $M = 0.150 \times 9.0^2 / 8 = 1.5 \text{ k/ft}$ $(3.0) \times 1.32$ (26.7)
 $0.900 \times 9.0 \times 1.3 = 10.5$ 1.3×1.67
 $(13.5) 12.0 \text{ k/ft} \times 1.3 \times 1.67 = 25.7 \text{ k/ft}$
 $K_m = 318, P = 0.0062$ $A_3 = 0.66 \text{ in}^2$ #6 @ 8 Both (Trans)
 $K_m = (66) (P = 0.0033)$ $(A_3 = 0.83)$ #5 @ 8 Top EW and
Both (Longit).
Beams: Use \rightarrow #7 @ 8 Both (Transv)

$l = 21'9" \text{ c/c}$
 $w = DL: 12" \text{ slab}$ $150 \times 3.75' = 0.56 \text{ k/ft}$ $(1.12) \text{ k/ft}$
 $18 \times 24" \text{ Bms}$ $= 0.95$ $(1.09 \times 1.4 = 1.53)$
 $Hatch @ 30 \text{ psf} \times 2.55 = 0.08$ (1.65) (2.31)
 $LL @ 300 \text{ psf} (3.75 + 1.5 + 2.55) = 2.34 \text{ k/ft} \times 1.7 = 3.98 \text{ k/ft}$
 $M_u = 5.51 \times 21.75^2$ $(372.) \times 1.3 = 484$ $w = 3.43 \text{ k/ft}$ $w_u = 5.51 \text{ k/ft}$
 $V_u = 57.2 \text{ k}$ $(54.29) \text{ k}$ (54.13 k) $d = 21"$ (6.29)
 $F = 0.662$ (0.882)
 $K_m = 640$ (549)
 $P = 0.0135$ (0.0173)
 $A_3 = 5.10 \text{ in}^2$ 7 #8 Both
(5.69 in²) 2 #8 Top
 $\phi V_c = 0.85 \times 2 \sqrt{4000} \times 18 \times 21 = 40.6 \text{ k}$
 $\phi V_c = 7.0 \text{ k}$ #4 @ 10" c/c thru out
 $\phi V_c / K_u d = 0.016$
(See Shd. 10 - Top slab, t = 24" w/o Bms) (8 #8 Both in 24" width)



CITY OF HOUSTON		3904-00	
PROJECT		JOB NO. 0101	
5TD Pump STN - 3 Pumps -		9	
SUBJECT 2000 - 5300 GPM/P		SHEET	
ADMP	10.31.94	JAM	11-7-94
DESIGNED	DATE	CHECKED	DATE

VALUE VAULT: WALLS:



$t = 12'' \quad h = 1'-6'' + 9'-2\frac{1}{2}'' + 1'-0'' = 11'-8\frac{1}{2}'' = 11.7'$

$\frac{P_T}{P_B} = 0.096 \quad P' = \frac{100 + 1036}{2} \times 11.7 = 6.65k$

$M_{max} = \frac{6.65 \times 11.7}{7.82} = 9.9 k/ft$

$M_{all} = 1.7 \times 1.3 \times 9.9 = 22.0 k/ft$

$F = 0.081$

$K_m = 272$

$\rho = 0.0053$

$A_s = 0.57 in^2/ft$

#6 @ 8" Vert. LF.

#5 @ 8" Vert. DF.

#4 @ 12" Horiz. EF.

$t = 12'' \quad d = 12'' - 2\frac{1}{2}'' - \frac{1}{2}'' = 9''$

$t = 16'' \quad d = 13'' \quad F = 0.169$

$K_m = 130 \quad \rho = 0.0025$

$\rho_{min} = 0.0033$

$A_s = 0.51 in^2 \quad \#6 @ 8'' (0.66) \text{ Vert. LF.}$

BASE SLAB:

Loads Top slab DL = 150 psf

LL = 300

Walls $(2 \times 20.5 + 20.75) \times 10.20 / 50 = 202 psf \times 1.4 = 284$

$\times 1.4 = 210$

$\times 1.7 = 510$

$A = 19.50$

$B = 21.75 \quad m = 0.90$

$\frac{1004 \times 1.3}{12} = 1305 psf$

$d = 16 - 3 - 1 = 12''$

$F = 0.144$

$M_A = 1.31 \times 0.045 \times 19.5^2 = 22.4 k/ft$

$M_B = 0.029 \times 1.31 \times 21.75^2 = 18.0 k/ft$

$K_{NA} = 156, \rho_A = 0.0031, \rho_{min} = 0.0033$

$A_s = 0.48 in^2$

$K_{NB} = 125, \rho_B = 0.0024$

#5 @ 8" Top EW

#5 @ 12" Both. EW

check Buoyancy:

$T_{bu} = \left. \begin{matrix} \text{Top slab} = 210 \\ \text{Wall} = 9 - 2\frac{1}{2} \\ \text{Base} = 1 - 6 \end{matrix} \right\} = 12 - 8\frac{1}{2}'' \text{ lift} = 62.4 \times 12.70' = 792 psf$

DL = 24 slab = 300

12" walls = 202

18" Base slab = 225

645 psf



CITY OF Houston		3904c	
PROJECT			JOB NO. 01
37 D.P.S. - 3 Pumps		10	
SUBJECT	2000-5300 GPM/Ea		SHEET
NMB	11-2-94	JAM	11-7-94
DESIGNED	DATE	CHECKED	DATE

Consider 1'-0" ftg. three side
 Buoyant wt of ledge soil

$$(2 \times 20.5 + 24.75) \times 11.7 \times 0.060 = 46.2^k = 100 \text{ psf}$$

$$\Sigma W_{DL} = 645 + 100 = 745 \text{ psf} \downarrow < 792 \text{ psf} \uparrow$$

for F.S. against buoyancy = 1.20

$$\Delta D \downarrow = (1.2 \times 792 - 745) = 205 \text{ psf}$$

✓ Extend base slab 2'-0" beyond 1'-4" thick walls

$$\begin{aligned} \text{Soil wt} &= (2 \times 20.5 + 27.58) \times 11.7 \times 2 \times 0.06 = 96.3^k = 201 \text{ psf} \\ \text{1'-4" wall} &= (2 \times 20.5 + 23.42) \times 9.2' \times 1.33 \times 150 = 118.2^k = 246 \text{ psf} \end{aligned}$$

$$\begin{aligned} \Sigma W_{DL} &= 300 \\ &246 \\ &225 \\ &201 \\ \hline &972 \text{ psf} \end{aligned}$$

$$FS = \frac{972}{792} = 1.23$$

All: Top slab w/o Beams:

l = 21'-9" (max)
 w = 24" slab

$$\begin{aligned} &= 300 \text{ psf} \times 1.4 = 420 \\ &= 300 \text{ psf} \times 1.7 = 510 \\ W &= 600 \text{ psf} \end{aligned}$$

$$M_{DL} = 0.30 \times 21.75^2 / 8 = 17.7 \text{ k/ft} \times 1.0 \times 1.3 = 23.0 \text{ k/ft}$$

$$M_{IL} = 0.30 \times 21.75^2 / 8 = 17.7 \text{ k/ft}$$

$$OR \quad 0.9 \times 21.75 \times 1.3 = 25.4 \text{ k/ft} \quad \left(\begin{array}{l} \text{Impact} \\ \text{AASHTO} \\ \text{FACTORS} \end{array} \right) \times 1.67 \times 1.3 = 55.1 \text{ k/ft}$$

$$d = 21'' \quad F = 0.441 \quad P_m = 177 \quad \text{AASHTO FACTORS} \quad 78.1 \text{ k/ft}$$

$P = 0.0033$
 $A_3 = 0.84 \text{ in}^2$ #7 @ 8" Both parallel to Hatch, opngs.
 #5 @ 8" Dist. Reinf.



CITY OF HOUSTON, TX		3904-00	
PROJECT		JOB NO. 0101	
STD. P.S. - 3 PUMPS - 2000 - 5300 GPM EA.		11	
SUBJECT		SHEET	
NMP	11-2-94	JAM	11-7-94
DESIGNED	DATE	CHECKED	DATE

TOP SLAB: BEAMS BETWEEN HATCHES:

$b \times t = 11" \times 24"$
 $b \times t = 16" \times 24"$ $d = 20"$
 $l = 5'-0\frac{1}{2}" \left. \begin{matrix} 2-0 \end{matrix} \right\} = 7'-0\frac{1}{2}"$ $F = 0.400 \times 1.33 = 0.532$
 $\times 0.92 = 0.368$
 $W = DL @ 300 psf \times 1.33 = 400 \times 1.4 = 560 p/f.$
 $LL @ 300 psf \times 3.58' = 1074 \times 1.7 = 1826 "$
 $W_{LL} = 2386 p/f$
 $M = 2.39 \times 7.04^2 / 8 = 14.8 k \times 1.3 = 19.2 k$
 $V_{LL} = 2.38 \times 5.04 / 2 = 6.0 k$ ($\phi V_c > 0$) $1.2 + 20.8 = 22.0 k$
 $\phi V_c = 0.85 \times 2 \sqrt{4000 \times 16 \times 20} = 34.4 k$
 $\times 11 \times 20 = 23.65 k$
 $b = 11"$
 $F = 0.368, F_m = 62$ $f_{mic} = 0.0033$
 $A_3 = 1.06 in^2$ 2#8.78 BOT X 9'-0" Lg.
 $\# 3 \square @ 8" STIRRUPS.$

Valve Pad:

$A = 15'$
 $B = 18'-6"$ $m = 0.81$
 $W_{DL} = 150 p/f$ 175
 $W_{LL} = 150 p/f$ 255
 $W_{TOT} = 300 p/f$ $W_{TOT} = 430 p/f$
 $M_A = 0.061 \times 0.43 \times 15^2 = 5.9 k/f$
 $M_B = 0.023 \times 0.43 \times 18.5^2 = 3.4 k/f$
 $V_A = \frac{0.71 \times 15 \times 0.43}{2} = 2.29 k/f$
 $0.30 = 1.6 k/f$
 $d = 12'-3"-1' = 8"$
 $F = 0.064$
 $V_{inA} = 92$ ($f_{mic} = 0.0033$)
 $A_3 = 0.32 in^2 / ft$
 $\# 5 @ 12" BOT EW$
 $\# 5 @ 8" TOP EW$
 Gr. Wall $1.0 \times 2.5 \times 0.150 = 0.38$
 $1.98 k/f$
 bearing = $1.98 ksf$ ($3.00 ksf$ allowable)



HOUSTON, TX STDS		3921-00
PROJECT LP, SSC PUMP STN-EZ		JOB NO. 0101
3 PUMPS @ 2000-5300 GPM		1 of 7
SUBJECT LOW PROFILE - SECURED		SHEET
CEO DESIGNED	11/14/95	DATE
	NYMP	CHECKED
		11-21-95
		DATE

VALVE VAULT : 21'-2" X 24'-9" X 13'-0" w/ 2'-0" walls

GRATING : FRP = 25 psf
 LL = 150 psf
 175 psf

• DESIGN FOR CRITICAL BEAM - B-2

$L = 20'-9"$

$w = 175 \text{ psf} * \left(\frac{3.0' + 4.5'}{2} \right) = 656 \text{ plf}$

BEAM WT SAY = $\frac{44}{700} \text{ plf}$

$M = \frac{wl^2}{8} = \frac{.7 * 20.75^2}{8} = 37.7 \text{ k}$

$W = wl = .7 * 20.75 = 14.53 \text{ k}$

$V = w(l/2) = .7 * 20.75/2 = 7.27 \text{ k}$

FROM ALLOW. M IN BEAM CHART

W 10x33

$M_R = 50 \text{ k}$

$\Delta_{\text{approx}} = \frac{0.98 * 14.53}{28} = 0.51" = \frac{L}{488}$

$l_n = 20.75$

SINGLE PLATE SHEAR CONNECTION, TBL X-A PG 4-54

$\frac{3}{8}" \text{ PL} \times 6" \times 6"$ w/ $\frac{13}{16} \times 1\frac{7}{8}"$ LONG SLOTTED HOLES

(STEEL)

$V_{\text{allow}} = 8.2 \text{ k} > V = 7.27 \text{ k}$

FOR 2 - $\frac{3}{4}" \phi$ A325 BOLTS

REF. PCI 3RD ED. TBL G20.7

$V_u = 7.27 \text{ k} * 1.7 = 12.4 \text{ k} \ll \phi V_c = 12.2 \text{ k} / \text{stud } 2 - \frac{3}{4}" \text{ STUDS} = 24.4 \text{ k}$

WALL FACE PL = $\frac{3}{8}" \times 6" \times 8"$ w/ 2 - $\frac{3}{4}" \phi$ 6" LONG STUDS



HOUSTON, TX STDS PROJECT		3921-00 JOB NO. 0101
3 PUMPS @ 2000-5300 GPM SUBJECT LOW PROFILE - SECURED		2 of 7 SHEET
CEO DESIGNED	11-14-95 DATE	NTMYP CHECKED 11-21-95 DATE

VALVE VAULT

DESIGN FOR CRITICAL BEAM : B-4

$L = 20' - 9"$

$w = 175 \text{ psf} \times \frac{(5.17' + 5.5')}{2} = 934$

BEAM WT = $\frac{56}{990} \text{ p/f}$

$M = \frac{0.99 \times 20.75^2}{8} = 53.3 \text{ 'k}$

$W = 0.99 \times 20.75 = 20.6 \text{ k}$

$V = 10.3 \text{ k}$

CHOOSE W14 x 38 $M_R = 54.25 \text{ k}$

$l_u = 20.75'$

$\Delta_{approx} = \frac{0.70 \times 20.6}{43} = 0.34" = L$

SINGLE PLATE SHEAR CONNECTION T&L X-B PG 4-54

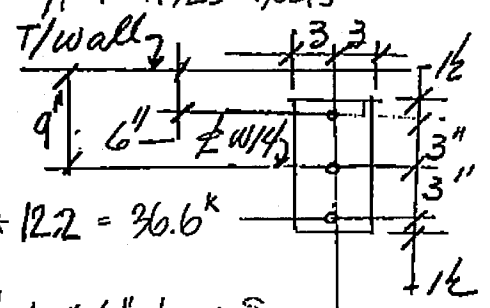
$\frac{3}{16}" \text{ PL} \times 6 \times 9$ w/ $\frac{13}{16} \times 1 \frac{7}{8}$ LONG SLOTTED HOLES FOR 3- $\frac{3}{4}" \text{ } \Phi$ A325 BOLTS

(STEEL) $V_{allow} = 16.3 \text{ k} > V = 10.3 \text{ k}$

REF: PCI 3RD ED. T&L 620.7

(CONC) $V_u = 10.3 \times 1.7 = 17.5 \text{ k} \ll \phi V_c = 3 \times 12.2 = 36.6 \text{ k}$

WALL FACE $\text{PL} = \frac{3}{8}" \times 6 \times 9$ w/ 3- $\frac{3}{4}" \text{ } \Phi \times 6"$ LONG STUDS



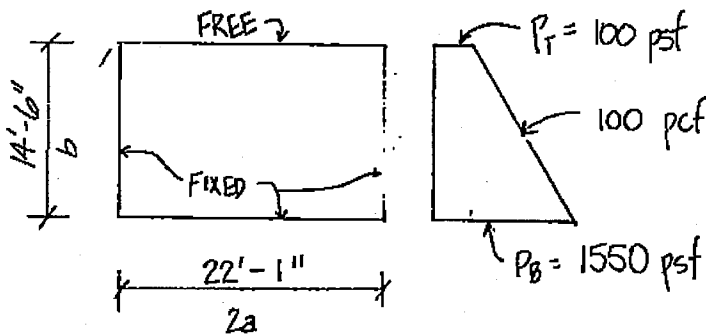


HOUSTON, TX STDS PROJECT		3921-00 JOB NO. 0101
3 PUMPS @ 2000-5300 GPM SUBJECT LOW PROFILE-SECURED		3 of 7 SHEET
CEO DESIGNED	11-14-95 DATE	NMP CHECKED 11-27-95 DATE

PIT WALLS

REF: BOR, EM No 27

END PANEL = 22'-1" x 14'-6"



$$a/b = \frac{22.08}{2 \times 14.5} = 0.75$$

$$P_T b^2 = 0.1 (14.5)^2 = 21.03 \text{ k}$$

$$P_T b = 1.45 \text{ k}$$

$$P_B b^2 = 1.45 (14.5)^2 = 304.9 \text{ k}$$

$$P_B b = 1.45 (14.5) = 21.02 \text{ k}$$

$$M_x^+ = (0.0807 \times 21.03) + (0.0214 \times 304.9) = 8.22 \text{ k/ft} \times 1.7 = M_{UH}^+ = 14.0 \text{ k}$$

$$M_x^- = (0.1788 \times 21.03) + (0.0433 \times 304.9) = 16.96 \times 1.7 = M_{UHORE}^- = 28.9 \text{ k}$$

$$M_y^- = (0.1212 \times 21.03) + (0.0584 \times 304.9) = 20.35 \times 1.7 = 34.6 \text{ k}$$

$$M_y^+ = (0.0245 \times 21.03) + (0.0143 \times 304.9) = 4.68 \times 1.7 = 8.3 \text{ k}$$

$$d_v = 16-2-1/2 = 13.5" \quad F_v = 0.182$$

$$d_h = 16-3-1/2 = 12.5" \quad F_h = 0.156$$

CODE: sect 10.5.2

$$K_H^+ = M_u / F_h = 90 \quad e_H^+ = 0.0017 \quad A_{S,MIN}^+ = e_H b d_H \times 4/3 = 0.53 \text{ #6 @ 14" H, 1F} \\ (0.0023) \quad (0.35)$$

$$K_H^- = 185 \quad e_H^- = 0.0035 \quad A_{SH}^- = 0.58 \text{ #6 @ 7" H OF C INTERS} \\ (0.0047) \quad (0.71)$$

$$K_v^+ = M_u / F_v = 46 \quad e_v^+ = 0.0013 \quad A_{SV,MIN}^+ = e_v \times b \times d_v = 0.53 \text{ #6 @ 14" Vert IF} \\ (0.0017) \quad (0.27)$$

$$K_v^- = 190 \quad e_v^- = 0.0036 \quad A_{SV}^- = 0.58 \text{ #6 @ 7" Vert} \\ (0.0048) \quad (0.76) \quad \text{DUAL OF}$$

$$P_{min} = 0.0033 \quad A_{3V,MIN} = 0.53 \text{ in}^2 \\ A_{3H,MIN} = 0.50 \text{ in}^2$$

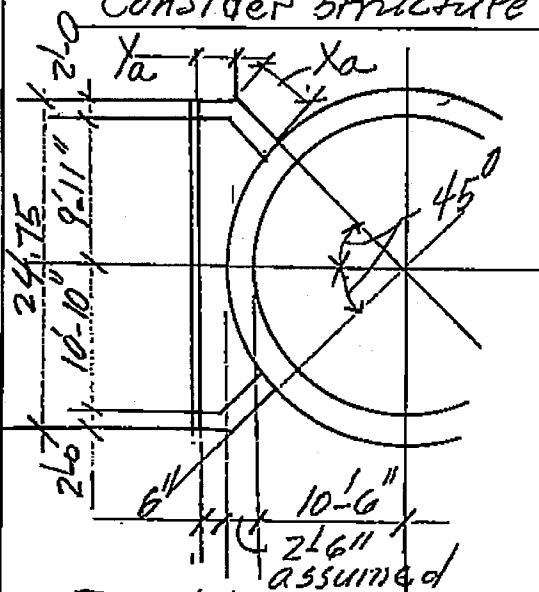


PROJECT		Houston, Tx, stds		JOB NO.	
SUBJECT		3 pumps @ 2000-5300 GPM LP secured		4 OF 7 SHEET	
DESIGNED	DATE	CHECKED	DATE		
NMP	4-26-96				

Buoyancy: Consider structure right of Exp. Joint:

24" Walls: $2 \times 13' \times 20.67' \times 2.0 \times 0.150 = 161.2 k$
 $1 \times 13' \times 20.75' \times 2.0 \times 0.150 = 80.9$
 30" Base Slab: $24.17 \times 31.75 \times 2.5 \times 0.150 = 287.8$
 $W_c = 529.9 k$
 3/4" Ftg Soil: $2 \times 3.5' \times 24.17' \times 12.5 \times 0.120 = 253.8 k$
 $1 \times 3.5' \times 24.75' \times 12.5 \times 0.120 = 129.9$
 2plift: $24.17 \times 31.75 \times 15.5' \times 0.062 = 737.5 k$
 $W_s = 383.7 k$
 $\frac{529.9}{1.10} + \frac{383.7}{1.50} = 481.7 + 255.8 = 737.5 k = F_u$

Consider structure between Exp. Jt and Wet Well:



$X_{ave} = \frac{24.75}{2 \times 0.707} - 13.0 = 4.50'$
 $Y_a = 13.5 - 12.38 = 1.12$
 Wall L = 5.62 ft
 Top slab area:
 $1.12 \times 24.75 = 27.7$
 $12.38 \times 12.38 = 153.3$
 $-\pi \times 13^2 / 4 = -132.7$
 $48.3 ft^2$
 Base slab area: $48.3 ft^2 + 2 \times 5.62 \times 3.5 = 87.6 ft^2$

Dead Loads:

Top slab: $48.3 \times 2 \times 0.150 = 14.5 k$
 Walls: $2 \times 2 \times 5.62 \times 11 \times 0.150 = 37.1$
 Base slab: $87.6 \times 2.5 \times 0.150 = 32.9$
 3/4" Ftg soil: $2 \times 3.5 \times 5.62 \times 12.5 \times 0.120 = 59.0 = W_s$
 $W_c = 84.5 k$
 2plift: $87.6 \times 15.5 \times 0.062 = 84.2 k = F_u$
 $\frac{84.5}{1.10} + \frac{59.0}{1.50} = 76.8 + 39.3 = 116.1 k > F_u$



HOUSTON, TX STDS		3921-00	
PROJECT		JOB NO. 1010	
3 PUMPS @ 2000-5300 GPM		5 of 7	
SUBJECT LOW PROFILE - SECURED		SHEET	
CEO	11-16-95	NMP	11-27-95
DESIGNED	DATE	CHECKED	DATE

BRACKET FROM WET WELL WALL:

CONSIDER 5' WIDE BASE SLAB & 5'-0" OF WALLS FROM VAULT SUPPORTED ON TO BRACKET.

$$\begin{aligned}
 P_{SLAB} &= 1'-6" \text{ SLAB @ } 225 \text{ psf} \times 5' = 1125 \text{ \#/ft} \\
 &LL @ 150 \text{ psf} \times 5' = 750 \\
 &1875 \text{ \#/ft}
 \end{aligned}$$

$$P_{WALL} = 0.150 \times 13' \times 5 \times 1.33 = 17.29 \text{ k}$$

$$W = 2'-6" \text{ SLAB} = 375 \text{ psf}$$

ASSUME WET WELL $t = 2'$

$$L_{min} = 1'-0"$$

$$L_{max} = (12.5' - 12.5 \cos 45) + 1.0' = 4.66'$$

$$L_{ave} = 2.83'$$

$$\begin{aligned}
 M_{AVE} &= 0.375 \times \frac{2.83^2}{2} = 1.50 \text{ 'k/ft} \\
 &1.875 \times 2.83 = 5.31 \\
 &6.81 \text{ 'k/ft}
 \end{aligned}$$

$$\begin{aligned}
 M_{MAX} &= 0.375 \times \frac{4.66^2}{2} = 4.07 \text{ 'k/ft} \\
 &1.875 \times 4.66 = 8.74 \text{ 'k/ft} \\
 &12.81 \text{ 'k/ft} \times 1.7 = 21.78 \text{ 'k/ft}
 \end{aligned}$$

$$d = 30'' - 2'' = 28'' \quad b = 12''$$

$$F = 0.729 \quad K_n = 30 \quad \rho_{min} = 0.0018 \quad A_s = 0.58 \frac{in^2}{ft} \#6 @ 9" (0.59)$$

WALL AS BRACKET: $L = 4.6'$

$$P_{WALL} = 17.29 \text{ k} \downarrow \quad W = 2.6 \text{ k/ft} \downarrow$$

OR

$$P_{UPLIFT} = 83.2 \text{ k} \uparrow$$

$$\begin{aligned}
 M_{DL} &= 17.29 \times 4.6 = 79.5 \text{ k} \\
 &2.6 \times \frac{4.6^2}{2} = 27.5 \\
 &107.0 \text{ k}
 \end{aligned}$$

$$M_{UPLIFT} = 83.2 \text{ k} \times 4.6 = 382.7 \text{ k}$$



Houston, Tx. Stds.		3921.00
PROJECT		JOB NO. 0191
3 Pumps at 2000-5300 GPM		6 of 7
SUBJECT Low Profile - Secured		SHEET
NMP	11-28-95	
DESIGNED	DATE 5-3-96	CHECKED
		DATE

Ref: PCA - "Simplified Design" Shear Wall, pg 6-13.

$M_{u1} = 1.4 \times 107 = 150 \text{ kft}$

$M_{u2} = 1.7 \times 382.7 = 651 \text{ kft}$ controls

$$\phi M_n = \phi \left[0.5 A_{st} f_y l_w \left(1 + \frac{P_u}{A_{st} f_y} \right) \left(1 - \frac{e}{l_w} \right) \right]$$

where $\phi = 0.9$

$A_{st} = \#6 @ 12 \text{ EF} = 0.44 \times 2 \times 13 = 11.44 \text{ in}^2$

$l_w = 13 \times 12 = 156 \text{ in}$ $h = 24 \text{ in}$, wall thickness

$P_u = 0$

$$\frac{e}{l_w} = \frac{w + \alpha}{2w + 0.85 \beta_1}$$

$$= \frac{0.046}{2 \times 0.046 + 0.722}$$

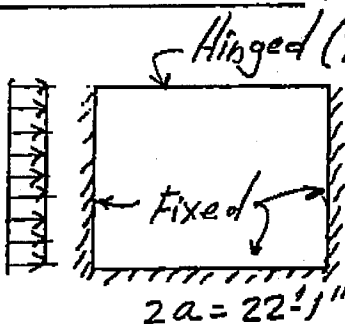
$$= 0.057$$

where $\alpha = 0$ for $P_u = 0$
 $\beta_1 = 0.85$ for $f_c \leq 4000$
 $w = \frac{(A_{st}) f_y}{(l_w h) f_c}$
 $= \frac{11.44 \times 60}{156 \times 24 \times 4} = 0.046$

$$\phi M_n = 0.90 \times 0.5 \times 11.44 \times 60 \times 156 \times 0.99 / 12$$

$$= 3774 \text{ kft} > 651 \text{ kft}$$

Base Slab:



$t = 30 \text{ in}$ $F = 0.529$
 $d_{min} = 28 - 3 - 2 = 23 \text{ in}$
 $A_{min} = 0.0018$
 $A_{smin} = 0.50 \text{ in}^2/\text{ft}$

Net uplift = $15.5 \times 0.0624 = 0.967 \text{ ksf}$
 $- 2.50 \times 0.150 = -0.375 \text{ ksf}$
 $p = 0.592 \text{ ksf}$

Ref: BOR EM.

$b = 19'-4 \text{ in}$ $p b = 11.4$ $a/b = 0.57 < 0.5$
 $p b^2 = 221$ < 0.75

$M_x^- = 0.0695 \times 221 = 15.4 \text{ kft}$ $M_{ux}^- = 26.2 \text{ kft}$

$M_x^+ = 0.0263 \times 221 = 5.8$ $M_{ux}^+ = 9.9$

$M_y^- = 0.0898 \times 221 = 19.8$ $M_{uy}^- = 33.7$

$M_y^+ = 0.0473 \times 221 = 10.5 \text{ kft}$ $M_{uy}^+ = 17.9 \text{ kft}$

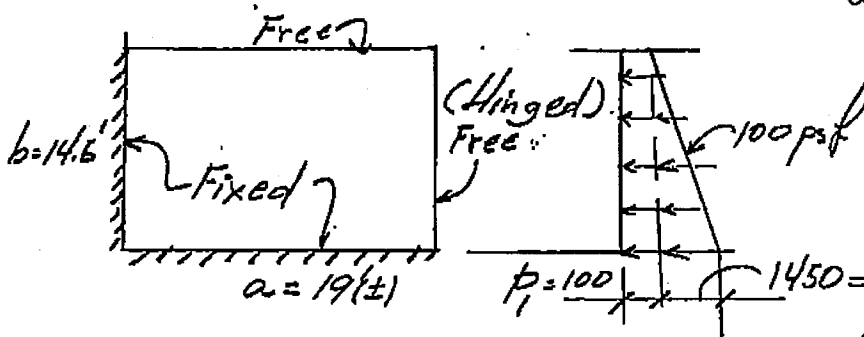
$K_{nx}^- = 50$ $K_{nx}^+ = 19$ $K_{ny}^- = 64$ $K_{ny}^+ = 34$
 $A_{smin} = 0.50 \text{ in}^2/\text{ft}$ (average) $< 0.45 \text{ in}^2/\text{ft} \#6 @ 12$
 $(\pm 10\% \text{ Distr.})$ $< 0.56 \text{ in}^2/\text{ft} \#6 @ 7$ at wall. Bott.



Houston Tx, std.		3921-00
PROJECT		JOB NO. 0101
3 pumps at 2000-5300 GPM		7 of 7
SUBJECT		SHEET
NMP	11-28-95	
DESIGNED	DATE 5-3-96	CHECKED
		DATE

Valve Pit - Side walls: Ref: BOR, EM. No. 27

$a/b = 19/14.5 = 1.31 \approx 1.00$



$p_1 b = 0.1 \times 14.5 = 1.5$
 $p_1 b^2 = 0.1 \times 14.5^2 = 21$
 $p_2 b = 1.45 \times 14.5 = 21$
 $p_2 b^2 = 1.45 \times 14.5^2 = 305$

$M_x^- = 0.2949 \times 21 + 0.0662 \times 305 = 26.4 \text{ k/ft}$ $M_{ux}^- = 44.9 \text{ k/ft}$
 $M_x^+ = 0.0324 \times 21 + 0.0077 \times 305 = 3.0$ $M_{ux}^+ = 5.1$

$* M_y^- = 0.2949 \times 21 + 0.1157 \times 305 = 41.5 \text{ k}$ $M_{uy}^- = 70.5 \text{ k/ft}$
 $M_y^+ = 0.0324 \times 21 + 0.0172 \times 305 = 5.9 \text{ k}$ $M_{uy}^+ = 10.0 \text{ k/ft}$

$t = 24''$ $d_H = 24 - 3\frac{1}{2} - \frac{1}{2} = 20.0$ $F = 0.40$
 $d_V = 24 - 2\frac{1}{2} - \frac{1}{2} = 21.0''$ $F = 0.44$

$K_{nx}^- = 112$	$P_H^- = 0.0021$	$A_{3H}^- = 0.50 \text{ in}^2/\text{ft}$	#6 @ 7" @ Inters.
$K_{nx}^+ = 13$	$P_H^+ = 0.0015$	$A_{3H}^+ = 0.36 \text{ in}^2/\text{ft}$	#6 @ 14" Cont.
$* K_{ny}^- = 160$	$P_V^- = 0.0030$	$A_{3V}^- = 0.76 \text{ in}^2/\text{ft}$	#6 @ 7" Vert. dw/s
$K_{ny}^+ = 23$	$P_V^+ = 0.0015$	$A_{3V}^+ = 0.38 \text{ in}^2/\text{ft}$	#6 @ 14" Vert. dw/s

Use this.

(* Consider Vert. Edges Hinged: $a/b = \frac{19}{2 \times 14.5} = 0.66$

$M_y^- = 0.2135 \times 21 + 0.0871 \times 305 = 31.0 \text{ k/ft}$ $M_u = 52.8 \text{ k/ft}$

$K_{ny}^- = 120$ $P = 0.0023$ $A_{3y}^- = 0.58 \text{ in}^2/\text{ft}$ #6 @ 9" VOF dw/s.



HOUSTON, TX STD		3921-00	
PROJECT LP-55C - Pump STN - FZ		JOB NO. 0101	
SUBJECT 4 Pumps - 500-2500 GPM		1 of 4	
Secure Site Pump Stn		SHEET	
DESIGNED NMP	DATE 11-30-95	CHECKED	DATE

VALUE VAULT: 15'-0" X 25'-6" X 8'-8" WALLS, t = 12":

Grating - FRP wt. = 25 PSF

LIVE LOAD = 150 PSF

W = 175 PSF

Support Beams:

Beam B1 - L = 23'6"

W = 175 (4.33 + 3.17) = 656 plf

wt. of Bm = 44 " (assumed)

M = 0.7 X 23.5² / 8 = 48.31k

V = 0.7 X 23.5 / 2 = 8.2 k

W = 16.4k

W10X39 lu = 23.5'

MR = 63 k

$\Delta_{1/2} = \frac{1.08 X 16.4}{23.0} = 0.77 \text{ in}$

W12X26 lu = 12'

MR = 50 k

Provide 3-3/4" Bolt Conn.

Beam B2: L = 23'6"

W = 175 (3.17 + 2.75) = 518 plf

wt. of Bm = 32

M = 0.55 X 23.5² / 8 = 38 k

V = 0.55 X 23.5 / 2 = 6.46 k

W = 0.55 X 23.5 = 12.93 k

2k. Provide 2-3/4" Bolt Conn.

W8X24 lu = 12'

MR = 39 k

$\Delta_{WB} = \frac{5 X 12.93 X (23.5 X 178)}{384 X 29 X 10^3 X 82.8} = 1.57 \text{ in} = \frac{L}{180}$ ok

$\Delta_{WB} = \frac{5 X 12.93 (23.5 X 12)^3}{384 X 29 X 10^3 X 170} = 0.77 \text{ in}$

W10X33 lu = 23.5'

MR = 43 k

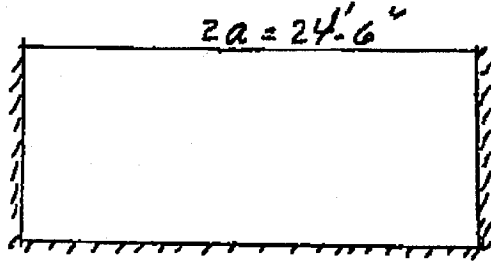
= $\frac{L}{366}$



Houston Tx Stds.		3921-00
PROJECT		JOB NO. 0101
4 Pumps - 500-2500 GPM		2 of 4
SUBJECT		SHEET
DESIGNED	12-4-95	CHECKED
	DATE	DATE

VALVE PIT WALLS:
Back wall:

$$a/b = \frac{24.5}{2 \times 9.67} = 1.26$$



$$\begin{aligned}
 p_1 b &= 1. \\
 p_1 b^2 &= 9.4 \\
 p_2 b &= 9.4 \\
 p_2 b^2 &= 90.4
 \end{aligned}$$

$$p_1 = 100 \text{ psf}, \quad p_2 = 96.7$$

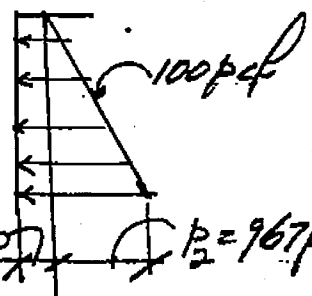
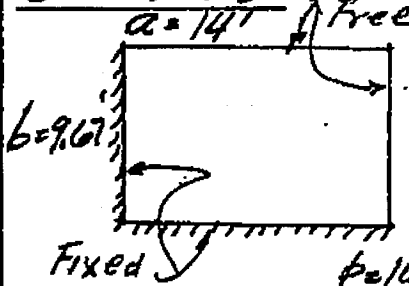
$$\begin{aligned}
 M_x^- &= 0.2959 \times 9.4 + 0.0751 \times 90.4 = 9.57 \text{ k} & M_u &= 16.3 \text{ k/ft} \\
 M_x^+ &= 0.0937 \times 9.4 + 0.0257 \times 90.4 = 3.2 \text{ k} & &= 5.4 \\
 M_y^- &= 0.2776 \times 9.4 + 0.1054 \times 90.4 = 12.1 & &= 20.7 \text{ k/ft} \\
 M_y^+ &= 0.0206 \times 9.4 + 0.0127 \times 90.4 = 1.3 \text{ k} & &= 2.2
 \end{aligned}$$

$t = 12''$ wall, $d_H = 8.5''$ $f_H = 0.07$
 $d_V = 9.5''$ $f_V = 0.09$

$K_H^- = 233$	$\rho = 0.0045$	$A_{2H}^- = 0.46 \text{ in}^2/\text{ft}$	#5 @ 12" O.C. CORN.
$K_H^+ = 77$	$\rho_{min} = 0.0033$	$A_{2H}^+ = 0.34 \text{ in}^2/\text{ft}$	#5 @ 12" HEF.
$K_V^- = 230$	$\rho = 0.0044$	$A_{3V}^- = 0.50 \text{ in}^2/\text{ft}$	#5 @ 6" V OF CORN.
$K_V^+ = 24$	$\rho_{min} = 0.0033$	$A_{3V}^+ = 0.138 \text{ in}^2/\text{ft}$	#5 @ 12" V EF.

Side wall:

$$a/b = 14/9.67 = 1.45 \rightarrow \text{use } = 1.00$$



$$\begin{aligned}
 p_1 b &= 1.0 \\
 p_1 b^2 &= 9.4 \\
 p_2 b &= 9.4 \\
 p_2 b^2 &= 90.4
 \end{aligned}$$

$$p_1 = 100 \text{ psf}, \quad p_2 = 96.7 \text{ psf}$$



HOUSTON, TX STDS		3921-00
PROJECT		JOB NO. 0101
4 Pumps - 500-2500 GPM		3 of 4
SUBJECT		SHEET
NMB	12-4-95	
DESIGNED	DATE	CHECKED
		DATE

$$\begin{aligned}
 M_x^- &= 0.2949 \times 9.4 + 0.0662 \times 90.4 = 8.8 \text{ k/ft}, & M_u &= 14.9 \text{ k/ft} \\
 M_x^+ &= 0.0324 \times 9.4 + 0.0077 \times 90.4 = 1.0 & &= 1.7 \\
 M_y^- &= 0.2949 \times 9.4 + 0.1157 \times 90.4 = 14.2 & M_u &= 24.2 \text{ k/ft} \\
 M_y^+ &= 0.0324 \times 9.4 + 0.0172 \times 90.4 = 1.9 & &= 3.2 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 K_H^- &= 213, & P &= 0.0041, & A_{SH}^- &= 0.43 \text{ \#5 @ 12" O.C. @ Corner} \\
 K_H^+ &= 24, & P_{min} &= 0.0033, & &= 0.34 \text{ \#5 @ 12" HEF.} \\
 K_V^- &= 269, & P &= 0.0052, & A_{SV} &= 0.59 \text{ \#5 @ 6" O.C. OF DWLS} \\
 K_V^+ &= 30, & P_{min} &= 0.0033, & &= 0.38 \text{ \#5 @ 12" VEF.}
 \end{aligned}$$

Base Slab

DEAD LOADS: 12" walls $2 \times 14.5 \times 8.67 \times 0.150 = 37.7 \text{ k}$
 $1 \times 23.5 \times 8.67 \times 0.150 = 30.6$
 16" Base slab $14.5 \times 25.5 \times 0.200 = 74.0$

2'-0" ftg. Soil wt. $2 \times 2' \times 16.5 \times 10.0 \times 0.06 = 39.6$ $\frac{142.3 \text{ k}}{39.6}$
 $1 \times 2' \times 23.5 \times 10.0 \times 0.06 = 28.2$ $\frac{28.2}{240.1 \text{ k}} \downarrow$

Uplift = $14.5 \times 25.5 \times 10.0 \times 0.0624 = 230.7 \text{ k}$

F.S against Uplift = $240.1 / 230.7 = 1.04$

Resisting force required = $1.25 \times 230.7 = 288.4 \text{ k}$

or Force transferred to wetwell $\frac{288.4 - 240.1}{2} = 48.3 \text{ k} \uparrow$
 by Wall Bracket, $\frac{48.3}{2} = 24.2 \text{ k}$ Each wall.

Assume wet-well wall $t = 2'0"$

Wall bracket Length = $\sqrt{13.0^2 + 12.5^2} - 12.5 = 5.53'$

$M_{Br} = 24.2 \times 5.53 = 134 \text{ k}$

$M_u = 1.7 \times 134 = 228 \text{ k}$

Wall bracket $t = 12"$ w/ #6 @ 12" EFW Reinf.

Ref: PCA "Simplified Design" shear walls pg 6-13.

$$\phi M_n = \phi \left[0.5 A_{st} f_y l_w \left(1 + \frac{P_u}{A_{st} f_y} \right) \left(1 - \frac{e}{l_w} \right) \right]$$



CONSER TOWNSEND ENVIRODYNE ENGINEERS, INC.

PROJECT		HOUSTON, TX STDS		3921-00	
SUBJECT		4 PUMPS - 500-2500 GPM EA.		JOB NO. 0101	
DESIGNED	NMP	DATE	12-4-95	CHECKED	
				SHEET	4 OF 4
				DATE	

$P_u = 0$
 $A_{3t} = 0.44 \times 2 \times 8 = 7.04 \text{ in}^2$

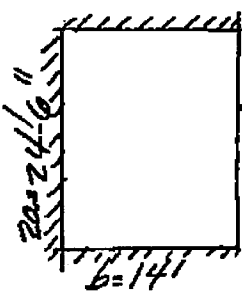
$l_w = 8'8" = 104"$

$\omega = \frac{A_{3t} f_s}{l_w h f_c'} = \frac{7.04 \times 60}{104 \times 12 \times 4} = 0.085$

$\frac{c}{l_w} = \frac{\omega}{2\omega + 0.85\beta_1}$ $\beta_1 = 0.85$ for $f_c' = 4000 \text{ psi}$
 $= \frac{0.085}{0.17 + 0.72} = 0.095$

$\phi M_n = 0.90 \left[\frac{0.5 \times 7.04 \times 60 \times 104 \times 0.905}{12} \right] = 1490 \text{ k} \gg M_u = 228 \text{ k}$

BASE SLAB:



Net 2/lift = $0.062 \times 10' - 1.33 \times 0.150 = 0.420 \text{ k/ft}$
 $a/b = \frac{24.5}{2 \times 14} = 0.88$

Hinged (Dwls)

$P_b = 0.42 \times 14 = 5.88$
 $P_b^2 = 0.42 \times 14^2 = 82.3$
 $M_x^- = 0.0680 \times 82.3 = 5.6 \text{ k}$ $M_u = 9.6 \text{ k}$
 $M_x^+ = 0.0249 \times 82.3 = 2.0 \text{ k}$ $= 3.4$
 $M_y^- = 0.0996 \times 82.3 = 8.2$ $= 13.9 \text{ k}$
 $M_y^+ = 0.0540 \times 82.3 = 4.4$ $= 7.6$

$t = 16"$ $d_y = 16 - 2 - \frac{1}{2} - 1 = 12.5"$ $F = 0.156$
 $d_b = 16 - 3 - \frac{1}{2} - 1 = 11.5$ $F = 0.132$

$K_x^- = 73$ $\rho_{min} = 0.0018$ $A_s = 0.35 \text{ in}^2/\text{ft}$ #5 @ 6 Dwls from Top
 $K_y^- = 105$ (6 x 55 area)
 $K_y^+ = 48$ $A_s = 0.35 \text{ in}^2/\text{ft}$ #5 @ 12 EW Bottom #5 @ 8 EW TOP

$V_{y \text{ Hinge}} = 0.3922 \times 5.88 = 2.31 \text{ k/ft}$ $V_u = 3.92 \text{ k/ft}$ $M_u = 8.2 \text{ k/ft}$
 $= 0.2735 \times 5.88 = 1.6 \text{ k/ft}$ $M_u = 2.0 \text{ k/ft}$ $V_u = 2.73 \text{ k/ft}$
 $K_m = 53$ $\rho_{min} = 0.0018$ $A_s = 0.35 \text{ in}^2/\text{ft}$ #6 @ 12 Dwls from Wet

CITY OF HOUSTON		3904-00	
PROJECT	STD. LIFT STATION - 4 Pumps		JOB NO. 000
SUBJECT	500 - 2500 GPM Ea.	1	
DESIGNED	UMP	DATE	2-9-95
CHECKED		DATE	

WET WELL:

TOP SLAB:

LL: Equip. Equip. or min = 300 psf.
(No truck load considered).
DL: 24" thick slab w/o beams = 300 psf.

$$L_{max} = 2 \times \sqrt{0.5^2 - 1.89^2} + 2.0 = 22.66 \text{ ft}$$

$$M_{DL} = 0.300 \times 22.66^2 / 8 = 19.3 \text{ k}$$

$$M_{LL} = 19.3 \text{ k}$$

Additional moment due to opening: Eac. side of opening

$$\Delta M_u = 42.6 \times \frac{4.54}{2} = 96.7 \text{ k}$$

Consider distribution over 2' width

$$\Delta M_u = 48.4 \text{ k/ft}$$

$$\Sigma M_u = 77.7 + 48.4 = 126.1 \text{ k/ft}$$

$$K_m = 273 \quad \rho = 0.0053$$

$$A_s = 1.36 \text{ in}^2/\text{ft}$$

↓ - Saint. Factor

$$M_{uDL} = 1.4 \times 1.3 \times 19.3 = 35.1 \text{ k/ft}$$

$$M_{uLL} = 1.7 \times 1.3 \times 19.3 = 42.6 \text{ k/ft}$$

$$d = 24 - 2 \times \frac{1}{2} = 21.5 \text{ in}$$

$$F = 0.462$$

$$K_m = 168 \quad \rho = 0.0032$$

$$\rho_{min} = 0.0033$$

$$A_s = 0.85 \text{ in}^2/\text{ft}$$

#8 @ 8" Bolt (1.19 in²/ft).

#8 T&B Addl. @ Opening (2A_s = 1.58 in²)

#5 @ 8" T&B Bolt Temp Reinf.

VALVE VAULT:

TOP SLAB:

LL: Equip - Equip. Load or = 300 psf
(No truck load considered).

DL: 24" thick slab = 300 psf.

$$L_{max} = 24'-6"$$

Additional load from opening

$$LL = 300 \text{ psf} \times 2' / 3, 31' \text{ distribution} = 1.78 \text{ say } 200 \text{ psf.}$$

$$W_u = 1.4 \times 1.3 \times 300 = 546 \text{ psf}$$

$$1.7 \times 1.3 \times 500 = 1104 \text{ psf} \quad \} = 1650 \text{ psf.}$$



CITY OF HOUSTON		3904-00
PROJECT		JOB NO. 0100
STD. LIFT STATION - 4 PUMPS		2
SUBJECT	500-2500 GPM ED.	SHEET
NMP DESIGNED	2-10-95	CHECKED
DATE		DATE

$$M_u = 1.65 \times 24.5^2 / 8 = 124 \text{ k/ft}$$

$$V_{u2} = 1.65 \times \frac{(24.5 - 0.5 - 1.78)}{2} = 16.5 \text{ k/ft}$$

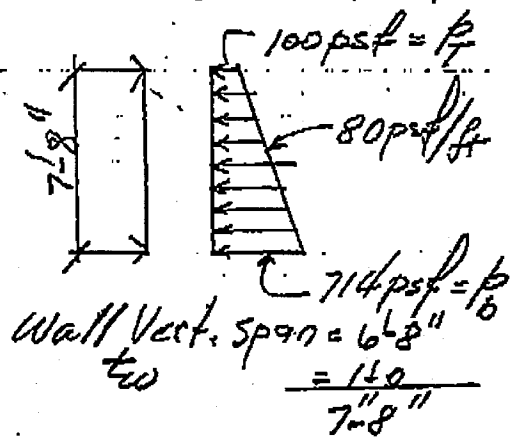
$$V_{u2, \text{max}} = 16.5 \times \frac{4.65}{3.78} = 20.4 \text{ k/ft} < \phi V_c = 2 \times 0.85 \sqrt{4000} \times 12 \times 21.5 = 27.7 \text{ k/ft}$$

$$K_m = 268 \quad \rho = 0.0052$$

$A_s = 1.34 \text{ in}^2/\text{ft}$ #8 @ 8" Bott.
 1 #8 T & Bott. add. at opening.
 #5 @ 8" T & Bott. temp. Reinf.

WALLS:

Consider flood condition with soil saturated to full height, w/ equiv. lateral pressure of 80 psf



$$p_t/p_b = 0.14$$

$$Q = \frac{100 + 714}{2} \times 7.67 = 3.12 \text{ k}$$

$$M = \frac{3.12 \times 7.67}{1.82} = 3.1 \text{ k/ft}$$

$$V_T = 0.35 \times 3.12 = 1.12 \text{ k/ft}$$

$$V_B = 0.65 \times 3.12 = 2.0 \text{ k/ft}$$

$$M_m = 1.7 \times 1.3 \times 3.1 = 6.9 \text{ k/ft}$$

$$d = 12" - 2 - \frac{1}{2} = 9.5" \quad F = 0.09$$

$$K_m = 77 \quad \rho = 0.0033 \text{ - use}$$

$$\rho = 0.0014 \quad \rho_{mn}$$

$$A_s = 0.38 \text{ in}^2/\text{ft} \quad \#5 @ 8" \text{ Vert. EF.}$$

$$\#4 @ 12" \text{ Horiz. EF.}$$



CITY OF HOUSTON		3904.00
PROJECT		JOB NO. 0100
STD LIFT STN - 4 PUMPS		3
SUBJECT	500-250.0 GPM EA.	SHEET
DESIGNED	NMP	
DATE	2-10-95	
CHECKED		
DATE		

VALUE VAULT BASE SLAB:

Loads: Top slab

$$DL: \frac{(25.5 \times 17.5 - 4 \times 4.04 \times 3.83) \times 300}{25.5 \times 17.5} = 258 \text{ psf}$$

$$LL: = 300 \text{ #}$$

walls

$$DL: \frac{(25.5 + 2 \times 16.5) \times 6.67 \times 1 \times 0.150}{25.5 \times 17.5} = 132 \text{ #}$$

soil on 1'-6" wide ledge

$$DL: \frac{28.5 \times 11.5 \times 9.17 \times 60 \text{ pcf} + 2 \times 17.5 \times 11.5 \times 9.17 \times 60 \text{ #}}{25.5 \times 17.5} = \frac{52.4 \text{ k}}{25.5 \times 17.5} = 117 \text{ #}$$

$$W_u = 1220 \text{ psf (1.5) } \times 2 \times 17.5 = 807 \text{ psf}$$

A = 17.5', B = 25.5', A/B = 0.69, B/A = 1.46 \approx 1.5 Two-way slab.
 PCA - Rect. Tanks Pg. 2.54.
 $\frac{90}{1000} = \frac{0.807 \times 17.5^2}{1000} = 0.247$

$M_{Aw} = 78 \times 0.247 = 19.3 \text{ k/ft} \times 1.51 \times 1.3 = 37.9 \text{ k/ft}$
 $M_{Bk} = 43 \times 0.247 = 10.6 \text{ k/ft} \times 1.51 \times 1.3 = 20.8 \text{ k/ft}$

$K_{mA} = 224, \rho = 0.0042, d = 16 - 2 - 1 = 13"$
 $A_z = 0.66 \text{ in}^2, F = 0.169$

#608 TOP EW.
 #5081EB EW.

Bouyancy check

$h_w = \text{Top slab} = 2'-0"$
 $\text{Wall ht.} = 6'-8"$
 $\text{Base slab} = 1'-6"$

DL: Top slab = 258 psf
 walls = 132 #
 soil = 117
 Base slab = 200
 707 psf

$$2 \text{ plift} = 62.4 \times 10.17 = 635 \text{ psf}$$

F.S. against floatation = $\frac{707}{635} = 1.11$

Try 2'-0" wide ledge

$$(29.5 + 2 \times 17.5) \times 2 \times 9.17 \times 60 = \frac{71 \text{ k}}{25.5 \times 17.5} = 159$$

$2 DL = 749 \text{ psf}, F.S. = \frac{749}{635} = 1.18 \approx 1.20$

VALVE PAD:

$A = 10.0 (\pm)$ $B/A = 2.00$
 $B = 20.0$

Loads = 12" slab
LL

$= 150 \text{ psf} \times 1.4 = 210$
 $= 300 \text{ psf} \times 1.7 = 510$
 $W = 450 \text{ psf}$ 720 psf

$M_{Aa} = 0.072 \times 100 = 7.2 \text{ k/ft}$

$\frac{9d^2}{1000} = 0.072 \times 100$
 1000

$M_{Bw} = 0.072 \times 38 = 2.7 \text{ k/ft}$

$d = 12 - 3 - \frac{1}{2} = 8.5$
 $F = 0.072$

$K_{na} = 100$ $P_{min} = 0.0033$

$A_3 = 0.34 \text{ in}^2/\text{ft}$ #5 @ 8" T & B EN.

$V_{Amax} = 0.51 \times 450 \times 10 = 2.3 \text{ k/ft}$

$V_{ave} = \frac{2}{3} \times 2.3 = 1.53 \text{ k/ft}$ 8" wide G-wall

Soil $F_s = 2.3 \text{ ksf}$ (3.00 ksf allowable.



HOUSTON TX STDS PROJECT LP, S'SE. PUMP STN-G2		3921-00 JOB NO. 0101
3 WET & 2 DRY WEATHER PUMPS SUBJECT SECURED SITE		1 OF 9 SHEET
NMP DESIGNED	12-4-95 DATE	CHECKED DATE

VALUE PIT No. 1 $21'-2" \times 25'-9" \times 13'-0"$ walls $t = 24"$
 Grating FRP wt = 2.5 psf
 LIVE LOAD = 150
 $w = 175 \text{ psf}$

SUPPORT BEAMS:

Beam B1. $L_1 = \frac{24'-5"}{2} = 21'-9"$

$w = 175 \frac{(3.17 + 5.0)}{2} = 715 \text{ plf}$
 Bm. wt = 35"

$M = \frac{0.75 \times 21.75^2}{8} w = 750 \text{ plf}$
 $M = 44.3 \text{ k}$

$V = \frac{0.75 \times 21.75}{2} = 8.2 \text{ k} = R$

$W = 0.75 \times 21.75 = 16.3 \text{ k}$

$\Delta = \frac{1.19 \times 16.3}{25} = 0.78" = \frac{L}{336}$

Use W10X33 $L_u = 21.75$
 $M_R = 47.5 \text{ k}$
 w/ 2-3/4" ϕ Bolt.
 Connection:
 3" PL w/ 5/16" weld
 $R = 8.2 \text{ k}$

Beam B2

$L_2 = 21'-9"$

$w = 175 \frac{(5.0 + 5.5)}{2} = 918 \text{ plf}$
 Bm. wt = 32"

$M = \frac{0.95 \times 21.75^2}{8} w = 950 \text{ plf}$
 $M = 56.2 \text{ k}$

$V = \frac{0.95 \times 21.75}{2} = 10.33 \text{ k} \quad R = 16.3 \text{ k}$

$W = 20.66 \text{ k}$

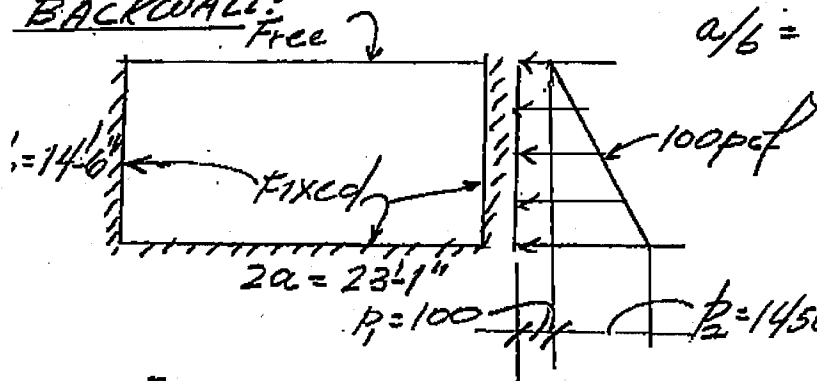
Use W12X40 $L_u = 21.75$
 $M_R = 68.8 \text{ k}$
 w/ 3-3/4" ϕ Bolts
 3" PL, 5/16" weld
 $R = 16.3 \text{ k}$

$\Delta = \frac{0.99 \times 20.66}{37} = 0.55" = \frac{L}{472}$



HOUSTON, TX, STDS		3921-00
PROJECT		JOB NO. 0101
3 WET & 2 DRY WEATHER PUMPS		2 OF 9
SUBJECT SECURED SITE		SHEET
NMP	12-4-95	
DESIGNED	DATE 5-3-95	CHECKED
		DATE

VALVE PIT WALLS: 20'-6" X 24'-5" X 13'-0" walls, 24" thickness
 BACKWALL: Free



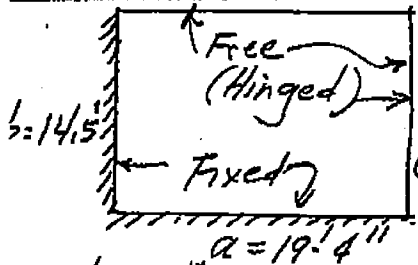
$a/b = 23.08/14.5 = 0.79$
 $p/b = 1.5$
 $p_1/b^2 = 21.0$
 $p_2/b^2 = 21.0$
 $p_2/b^2 = 305.0$

$M_x^- = 0.1788 \times 21 + 0.0433 \times 305 = 17.0 \text{ k/ft}$
 $M_x^+ = 0.0807 \times 21 + 0.0214 \times 305 = 8.2$
 $M_y^- = 0.1212 \times 21 + 0.0584 \times 305 = 20.4$
 $M_y^+ = 0.0242 \times 21 + 0.0139 \times 305 = 4.7$

$t = 24''$
 $d_H = 20.0'' \quad F_H = 0.40$
 $d_V = 21.0'' \quad F_V = 0.44$

$K_{NH}^- = 72, \quad P_H^- = 0.0013 \times 1/3 = 0.0017, \quad A_3^- = 0.40 \text{ in}^2/\text{ft} \quad \#6 @ 14 \text{ HOF at Corner}$
 $K_{NH}^+ = 35, \quad P_H^+ = 0.0013 \times 1/3 = 0.0017, \quad A_3^+ = 0.40 \text{ in}^2/\text{ft} \quad \#6 @ 14 \text{ HEF}$
 $K_{NV}^- = 79, \quad P_V^- = 0.0015 \times 1/3 = 0.0020, \quad A_3^- = 0.50 \text{ in}^2/\text{ft} \quad \#6 @ 7 \text{ DWL O.F.}$
 $K_{NV}^+ = 18, \quad P_V^+ = 0.0013 \times 1/3 = 0.0017, \quad A_3^+ = 0.40 \text{ in}^2/\text{ft} \quad \#6 @ 14 \text{ VEF}$

SIDE WALL: $a/b = 19.33/14.5 = 1.33 \approx 1.00$



$M_x^- = 0.2949 \times 21 + 0.0662 \times 305 = 26.4 \text{ k/ft}$
 $M_x^+ = 0.0324 \times 21 + 0.0077 \times 305 = 3.0$
 $M_y^- = 0.2949 \times 21 + 0.1157 \times 305 = 41.5$
 $M_y^+ = 0.0324 \times 21 + 0.0172 \times 305 = 5.9$

$t = 24''$
 $d_H = 20.0'' \quad F_V = 0.40$
 $d_V = 21.0'' \quad F_H = 0.44$

$K_{NH}^- = 112, \quad P_H^- = 0.0027 \times 1/3, \quad A_3^- = 0.67 \text{ in}^2 \quad \#6 @ 7 \text{ HOF @ Corners}$
 $K_{NH}^+ = 25, \quad P_H^+ = P_V^+ = 0.0013 \times 1/3, \quad A_3^+ = 0.40 \text{ in}^2 \quad \#6 @ 14 \text{ EF EW}$
 $K_{NV}^- = 160, \quad P_V^- = 0.0030 \times 1/3, \quad A_3^- = 0.72 \text{ in}^2 \quad \#6 @ 7 \text{ VOF Jwls. (*)}$



HOUSTON, TX STDS		3921-00
PROJECT		JOB NO. 01/1
3 WET & 2 DRY WEATHER PUMPS		3 OF 9
SUBJECT		SHEET
NMP	12-6-95	
DESIGNED	DATE 4-30-96	CHECKED
		DATE

(*) Consider Vertical Edges hinged = $a/b = \frac{19.33}{2 \times 14.5} = 0.67$
 $M_{y_{max}} = 0.2135 \times 21 + 0.0871 \times 305 = 31 \text{ k/ft}$ $M_{uy} = 57.8 \text{ k/ft}$
 $K_{ny_{max}} = 120$ $\rho = 0.0023 \times 1/3 \times \frac{1}{f_y} = 0.73 \text{ in}^2$ #6 @ 7" VOF dwls.

Base slab: Consider structure right of Exp. Joint:

Dead loads; 24" walls: $2 \times 20.67 \times 13.0 \times 2 \times 0.150 = 161.2 \text{ k}$
 $1 \times 21.75 \times 13.0 \times 2 \times 0.150 = 84.8$
 2'-6" Base slab: $24.67 \times 33.75 \times 2.5 \times 0.150 = 312.2$
 $W_6 = 558.2 \text{ k}$

Consider 4'-0" Footing projection

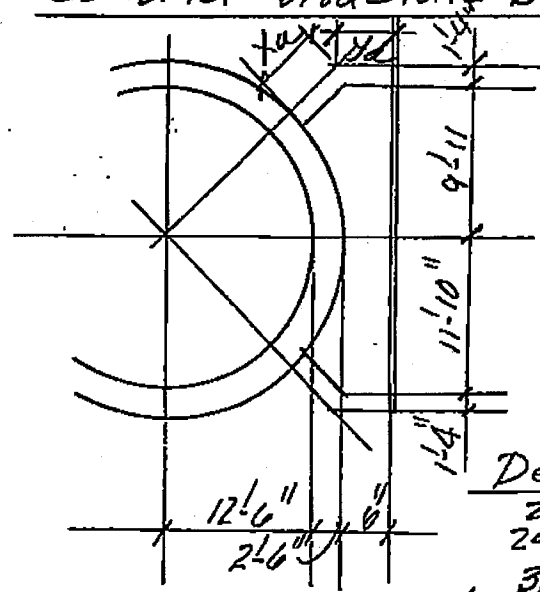
Soil. wt. $2 \times 24.67 \times 12.5 \times 4.0 \times 0.120 = 296.0 \text{ k}$
 $1 \times 25.75 \times 12.5 \times 4.0 \times 0.120 = 154.5$

2/plift: $24.67 \times 33.75 \times 15.5 \times 0.062 = 800.1 \text{ k}$ 450.5

$\frac{558.2}{1.10} + \frac{450.5}{1.150} = 507.5 + 300.3 = 807.8 \text{ k} > F_u = 800.1 \text{ k}$

$\frac{\Sigma W}{F_u} = \frac{1008.7}{800.1} = 1.26 \text{ ok}$

Consider structure between Exp. Jt and Wet Well:



$x_a = \frac{(11.92 + 13.83)}{2 \times 0.707} - 15.0 = 3.22'$

$y_a = 15.5 - 12.88 = 2.62'$
 ave. Wall $l = 5.84 \text{ ft}$

Top slab area = $2.62 \times 25.75 = 67.5$
 $12.87 \times 12.88 = 165.8$
 $- \pi \times 15^2 / 4 = -176.7$

Base slab area: $56.6 + 56.6 \text{ ft}^2$
 $2 \times 5.84 \times 4 = 103.3 \text{ ft}^2$

Dead loads:

24" Top slab: $56.6 \times 2 \times 0.150 = 17.0 \text{ k}$
 24" Walls: $2 \times 11 \times 5.84 \times 2 \times 0.150 = 19.3 \text{ k}$
 30" Base slab: $103.3 \times 2.5 \times 0.150 = 38.7$

Soil: $2 \times 5.84 \times 4 \times 12.5 \times 0.120 = 71.0 \text{ k}$ $W_6 = 75.0 \text{ k}$

2/plift = $103.3 \times 15.5 \times 0.062 = 99.3 \text{ k}$ $W_5 = 70.1 \text{ k}$



HOUSTON, TX - STDS

PROJECT

3921-00

JOB NO. 0101

3 Wet & 2 Dry weather Pumps 4 of 9

SUBJECT

SHEET

NMP

12-6-95

CHECKED

DATE

DESIGNED

DATE 4-30-96

$$\begin{aligned} \frac{\sum W_c}{1.10} + \frac{\sum W_s}{1.50} &= \frac{(558.2 + 75.0)}{1.10} + \frac{(450.5 + 70.1)}{1.50} \\ &= 575.6 + 347.1 \\ &= \underline{922.7 k} > \sum F_u = 800.1 + 99.3 = \underline{899.4 k} \end{aligned}$$

$$\frac{\sum W}{\sum F_u} = \frac{1153.8}{899.4} = \underline{1.28}$$

II Shear Capacity of Dwl. bars in Base slab: @ 12" c/c.

$$\phi V_c = 25.85 k$$

OR $\phi V_c = \phi V_c' c_w C_f C_c$

$$\phi V_c' = 24.52 k \quad d_c = 11''$$

$$c_w = 1.0 \quad n_s = 1$$

$$C_f = 1.0$$

$$h > 1.3 d_c = 14.3''$$

$$C_c = 1.0$$

$$d_c > d_e$$

$$\phi V_c = \underline{24.52 k} \text{ (control)} > V_u = 8.43 k$$

$$\phi V_s = 27.1 k$$

$$M_u = 8.43 \times 0.50 = 4.21'' k$$

$$f_{st} = 42.93 \text{ ksi}$$

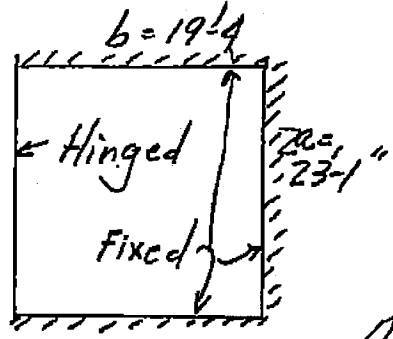
$$f_{sv} = \frac{8.43}{27.1} \times 60 = 18.66 \text{ ksi}$$

$$f_s = \sqrt{42.93^2 + 18.66^2} = \underline{46.81 \text{ ksi}} < f_s = 60 \text{ ksi.}$$



HOUSTON, Tx. STDS		3921-00-
PROJECT		JOB NO 0101
3 WET & 2 DRY WEATHER Pumps		5 OF 9
SUBJECT		SHEET
DESIGNED	DATE	CHECKED
NAP	12-6-95	
	5-3-96	
		DATE

Base slab:



$$a/b = \frac{23.08}{2 \times 19.33} = 0.60 < \begin{matrix} 0.50 \\ 0.75 \end{matrix} \quad 0.625$$

$$\text{Net uplift} = 0.062 \times 15.5 = 0.961$$

$$- 0.150 \times 2.5 = 0.375$$

$$0.586 \text{ k/ft} \uparrow$$

$$pB = 11.33$$

$$pB^2 = 219.$$

$$M_x^- = 0.0695 \times 219. = 15.2 \text{ k}, M_{ux} = 25.8 \text{ k}$$

$$M_x^+ = 0.0274 \times 219. = 6.0 = 10.2$$

$$M_y^- = 0.0898 \times 219. = 19.7 = 33.5$$

$$M_y^+ = 0.0473 \times 219. = 10.4 = 17.7 \text{ k}$$

$$V_{\text{Hing}} = 0.3874 \times 11.33 = 4.39 \text{ k/ft} \quad V_u = 7.46 \text{ k/ft}$$

$V_{\text{Hing}} = (\text{max})$

$$t = 30''$$

$$d_{\text{min}} = 28 - 3 - 2 = 23.0'' \quad F = 0.529$$

$$P_{\text{min}} = 0.0018 \quad A_{\text{min}} = 0.50 \text{ in}^2$$

- $K_{mx} = 49.$
- $K_{my} = 63.$
- $K_x^+ = 19.$
- $K_y^+ = 33.$

$$P_{\text{min}} = 0.0018 \quad A_3 = 0.50 < \begin{matrix} 0.45 \text{ m}^2 \#6 @ 12 \text{ TAB} \\ \text{EW} \\ 0.55 \text{ in}^2 \#6 @ 7 \text{ B} \\ \text{at walls.} \end{matrix}$$



HOUSTON, TX, STDS		3921-00
PROJECT LP. SSC PUMP STN-G2		JOB NO. 0101
SUBJECT 3 wet + 2 Dry Weather Pump		6 OF 9 SHEET
DESIGNED NMP	DATE 12-11-95	CHECKED
		DATE

VALUE PIT NO. 2: 14'-0" x 18'-10" x 8'-8" walls 1'-0" thick

Grafting FRP wt. = 25 psf
 Live Load = 150 psf
 W = 175 psf

Support beam:

$$w = 175 (4.33 + 2.25) = 575 \text{ plf}$$

$$P_{\text{m wt}} = \frac{25}{600} \text{ plf}$$

$$l = 16'-10"$$

$$M = 0.6 \times 16.83^2 / 8 = 21.2 \text{ k}$$

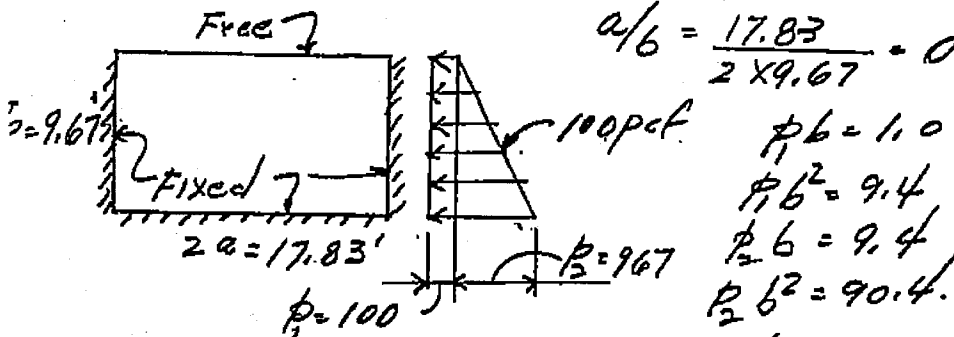
$$V = 0.6 \times 8.42 = 5.05 \text{ k}$$

$$W = 10.1 \text{ k}$$

W8x24 $l_n = 16.83'$
 $M_R = 33.5 \text{ k}$
 21se w/ 2-3/4" ϕ single
 3/8" Conn. w/ 5/16" weld
 $R = 8.2 \text{ k}$

$$\Delta = \frac{0.89 \times 10.1}{19} = 0.47" = \frac{1}{426}$$

End Wall: Ref: 215 Bureau of Reclamation, EM No. 27.



$$a/b = \frac{17.83}{2 \times 9.67} = 0.92 \approx 1.00$$

$$p_1 b = 11.0$$

$$p_1 b^2 = 9.4$$

$$p_2 b = 9.4$$

$$p_2 b^2 = 90.4$$

$$M_x^- = 0.2613 \times 9.4 + 0.0644 \times 90.4 = 8.3 \text{ k/ft}$$

$$M_x^+ = 0.1008 \times 9.4 + 0.0276 \times 90.4 = 3.4$$

$$M_y^- = 0.2043 \times 9.4 + 0.0845 \times 90.4 = 9.6$$

$$M_y^+ = 0.0243 \times 9.4 + 0.0159 \times 90.4 = 1.7$$

$$M_u = 14.1 \text{ k/ft}$$

$$= 5.9 \text{ k/ft}$$

$$= 16.3$$

$$= 2.8$$

$$t = 12" \quad d_y = 9.5" \quad F_v = 0.09$$

$$d_x = 8.5" \quad F_H = 0.07$$

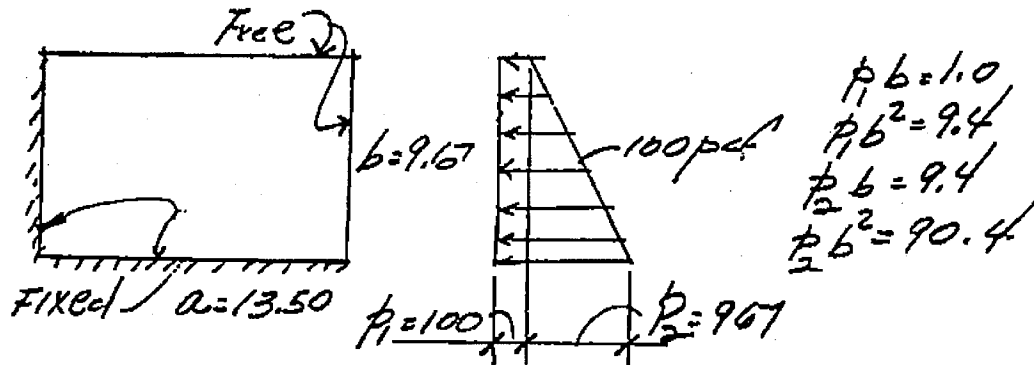


HOUSTON TX STDS		3921-00
PROJECT LP, SSC Pump Station		JOB NO. 0101
SUBJECT Wet + 2 Dry weather Pumps		7 of 9 SHEET
DESIGNED NMP	DATE 12-14-95	CHECKED
		DATE

$K_{mx}^- = 201.$ $P = 0.0039$ $A_3^- = 0.0039 \times 12 \times 8.5 = 0.40 \text{ in}^2/\text{ft}$ #5 @ 6" H
 $K_{mx}^+ = 84.$ $P_{min} = 0.0018$ $A_3^+ = 0.0018 \times 12 \times 12 = 0.26$ #5 @ 12" H
 $K_{my}^- = 181.$ $P = 0.0035$ $A_3^- = 0.0035 \times 12 \times 9.5 = 0.40$ #5 @ 6" DWL
 $K_{my}^+ = 31.$ $P_{min} = 0.0018$ $A_3^+ = 0.26$ #5 @ 12" VEF

Pit Side walls:

$a/b = 13.5/9.67 = 1.4 \approx 1.00.$



$M_x^- = 0.2949 \times 9.4 + 0.0662 \times 90.4 = 8.8 \text{ k/ft}$ $M_{ux} = 14.9 \text{ k/ft}$
 $M_x^+ = 0.0324 \times 9.4 + 0.0077 \times 90.4 = 1.0$ $= 1.7 \text{ k/ft}$
 $M_y^- = 0.2949 \times 9.4 + 0.1157 \times 90.4 = 13.2$ $= 22.5$
 $M_y^+ = 0.0324 \times 9.4 + 0.0172 \times 90.4 = 1.9$ $= 3.2$

$K_{mx}^- = 213.$ $P = 0.0041$ $A_3^- = 0.42 \text{ in}^2$ #5 @ 6" Corner
 $K_{mx}^+ = 24.$ $P_{min} = 0.0018$ $A_3^+ = 0.26 \text{ in}^2/\text{ft}$ #5 @ 12" HEF.
 $K_{my}^- = 250$ $P = 0.0049$ $A_3^- = 0.56 \text{ in}^2/\text{ft}$ #5 @ 6" dwls OF.
 $K_{my}^+ = 36.$ $P_{min} = 0.0018$ $A_3^+ = 0.26 \text{ in}^2/\text{ft}$ #5 @ 12" VEF.

Buoyancy check = Consider Structure, left of Exp. 1/1:

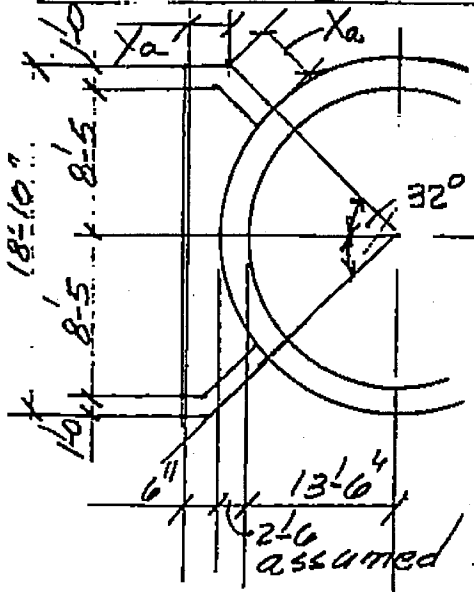
Dead loads:
 Walls: $2 \times 14 \times 8.67 \times 0.150 = 36.4 \text{ k}$
 $1 \times 16.83 \times 8.67 \times 0.150 = 21.9$
 3'-0" Ftg; 24" Base slab:
 $17.0 \times 24.83' \times 2' \times 0.150 = 126.6 \text{ k}$
 Soil: $2 \times 3.0 \times 8.17 \times 17.0' \times 0.120 = 100.$ $W_c = 184.9 \text{ k}$
 $1 \times 3.0 \times 8.17 \times 16.83 \times 0.120 = 49.5$

Uplift = $17.0 \times 24.83 \times 10.67 \times 0.062 = 279.2 \text{ k} = F_u$
 $W_c/1.10 + W_s/1.50 = 267.8 < F_u$ $\Delta W = -11.4 \text{ k}$



Houston, Tx STDS		3921.00	
PROJECT		JOB NO. 0101	
wet + 2 Dry weather pumps		8 OF 9	
SUBJECT		SHEET	
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DESIGNED	DATE	CHECKED	DATE

Consider structure between Exp. #1 and Wet Well:



$$Y_a = 15.50 - 14.0 = 1.50'$$

$$X_a = \frac{9.42}{0.53} - 16.0 = 1.78$$

$$\text{Wall } L = 3.28' \text{ (approx.)}$$

$$\text{Top slab arc: } 1.50 \times 18.42 = 27.6$$

$$2 \times \frac{1}{2} \times 9.42 \times 15.0 = 141.3$$

$$- \frac{\pi \times 16^2 \times 64}{360} = -147.9$$

$$= 26.0 \text{ ft}^2$$

$$\text{Base slab area} = 26.0 + 2 \times 3.28 \times 3.0$$

$$= 45.7 \text{ ft}^2 \text{ approx.}$$

Dead loads:

$$24'' \text{ Top slab} = 26 \times 2 \times 0.150 = 7.8 \text{ k}$$

$$12'' \text{ walls} = 2 \times 3.28 \times 6.67 \times 0.150 = 6.6$$

$$24'' \text{ Base slab} = 45.7 \times 2 \times 0.150 = 13.7$$

$$\text{Soil wt: } 2 \times 3.0 \times 8.17 \times 3.28 \times 0.120 = 24.1 \text{ k } W_c = 28.1 \text{ k}$$

$$\text{Uplift: } 45.7 \times 10.67 \times 0.062 = 30.2 \text{ k}$$

$$\frac{\sum W_c}{1.10} + \frac{\sum W_u}{1.50} = \frac{213}{1.10} + \frac{173.6}{1.5} = 309.4 \text{ k} = \sum F_u = 309.4 \text{ k}$$



HOUSTON, TX STDS		3921-00
PROJECT	LP, SSC Pump Station	JOB NO 0101
SUBJECT		9 of 9
SUBJECT		SHEET
NMP	12-14-95	
DESIGNED	DATE 5-3-96	CHECKED
		DATE

Consider Combined bending and shear of dowels:

$$M_u = V_u \times a = 0.50'' \times 7.37 = 3.69''k$$

$$f_{s\phi} = \frac{3.69}{0.7854 \times 0.5^3} = 37.59 \text{ ksi}$$

$$f_{su} = \frac{7.37 \times 60}{27.1} = 16.32 \text{ ksi}$$

$$f_c = \sqrt{37.59^2 + 16.32^2} = 40.98 \text{ ksi} < 60 \text{ ksi}$$

II Shear Capacity of 1" ϕ x 8'0" dwl in base slab:

$$\phi V_c = 25.85 \text{ k/dwl.}$$

or $\phi V_c = \phi V_c' C_u C_f C_c$ where $\phi V_c' = 15.2 \text{ k}$ $d_e = 8''$

$C_u = 1, n_s = 1,$
 $C_f = 1, h > 1.3 d_e = 10.4''$
 $C_c = 1, d_c > d_e$

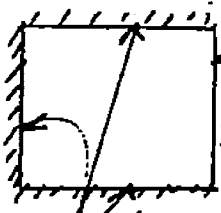
$$\phi V_c = 15.2 \text{ k/dwl.}$$

$$\phi V_s = 27.1 \text{ k/dwl.}$$

controls $\gg V_u = 4.66 \text{ k/ft or dwl.}$

Base Slab:

$$a/b = \frac{17.83}{2 \times 13.5} = 0.66$$



Hinged
 $2a = 17.83'$

Net Uplift = $10 \times 62.4 = 624$
 $- 1.33 \times 150 = -200 \text{ psf}$
 524 psf

$$p_b = 7.07$$

$$p_b^2 = 95.5$$

Fixed $b = 13.5'$

$$t = 24'' \quad d = 22 - 3 - 2 = 18.5'' \quad F = 0.342$$

$$M_x^- = 0.0695 \times 95.5 = 6.64$$

$$M_x^+ = 0.0274 \times 95.5 = 2.62$$

$$M_y^- = 0.0898 \times 95.5 = 8.58$$

$$M_y^+ = 0.10473 \times 95.5 = 4.52$$

$$M_u = 11.3 \text{ k/ft } K_n = 23.7$$

$$= 4.4 = 13.7$$

$$= 14.6 = 43$$

$$= 7.7 = 23$$

$$p_{min} = 0.0018$$

$$A_{smin} = 0.40 \text{ in}^2$$

$$V_{\text{hinge max}} = 0.3874 \times 7.07 = 2.74 \text{ k/ft}$$

$$V_u = 4.66 \text{ k/ft or } \#6 @ 12" TEW$$

$$\#5 @ 8" TEW$$

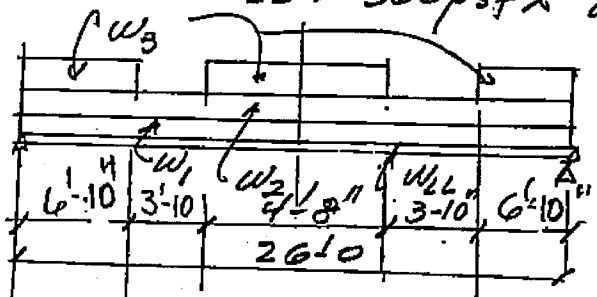


CITY OF HOUSTON		3904-00	
PROJECT		JOB NO. 0101	
LIFT STN W/O VALVE VAULT		12	
SUBJECT WET & DRY WR. PUMPS		SHEET	
NMP DESIGNED	11-1-94	JAM CHECKED	11-7-94
DATE		DATE	

WET WELL: TOP SLAB: (shf. C31)

Band 1: Consider 24" thick slab:
 $E = 3'-0\frac{3}{4}" = 3'-10"$
 $0-9\frac{1}{4}"$

$W = DL: W_1 = 300 \text{ psf} \times 3.83' = 1150 \text{ plf}$
 $W_2 = 30 \text{ psf} \times 4.75' = 143$
 $W_3 = 300 \times 2.25' = 675$
 $LL: 300 \text{ psf} \times 8.58' = 2574 = W_{LL}$



$M_u = 90.2 \times 13' = 1173,$
 $- 57 \times 6.5' = -371,$
 $- 23.5 \times 6.5 = -153,$
 $- 6.45 \times 11.83 = -76,$
 $- 2.23 \times 1.17' = -3,$

$LL \ 33.5 \times 1.7 = 57.0 \text{ k}$
 $W_1 + W_2 \ 16.82 = 23 \text{ k} \times 1.4 = 32.2 \text{ k}$
 $W_3 \ 6.2 = 23 \text{ k}$

$V_u = 89.2 \text{ k} < \phi V_c$

$\phi V_c = 0.85 \times 2 \sqrt{4000} \times 46 \times 21 = 103.9 \text{ k}$

$d = 21" \ (M_u = 741 \text{ k})$
 $F = 3.83 \times 0.441 = 1.689$
 $K_m = 337. (439)$
 $\rho = 0.0067 (0.0088)$
 $A_s = 6.47 \text{ in}^2 (8.50 \text{ in}^2)$
11 #8 Boff @ 4" c/c.

Band 2: $d = 21"$
 $b = 2.62 = 31" \ F = 1.14$

$l = 2 \sqrt{12.5^2 - 5.83^2} + 1.0 = 23.12 \text{ ft}$

$W_{DL} = 2.62' \times 300 \text{ psf} = 0.79$
 $30 \text{ psf} \times 2.5 = 0.08$
 $0.87 \times 1.4 = 1.22 \text{ k/ft}$

$W_{LL} = 300 \text{ psf} \times 5.12' = 1.54 \times 1.7 = 2.61 \text{ k/ft}$

$M_u = 3.83 \times 23.12^2 / 8 = 256 \text{ k} (333)$
 $K_m = 225. \rho = 0.0044 (0.0057) V_u = 42.4 \ V_{u2} = 35.7$
 $A_s = 2.8 \text{ in}^2 \ (3.71) \ [5 \#8 @ 7" c/c \text{ Boff.}]$
 $\phi V_c = 35 \text{ k} \neq V_{u2}$



CITY OF HOUSTON, TX		3904-00-
PROJECT		JOB NO. 0101
LFT STN W/O VALVE VAULT		13
SUBJECT	3 WET & 2 DRY PUMPS	SHEET
NMP	11-2-94	JAM
DESIGNED	DATE	CHECKED
		11-7-94
		DATE

Band 3: $l = 4.62 \left. \begin{array}{l} \\ \\ \end{array} \right\} 6.55'$
 2.0

$w = DL = 300 \times 1.4 = 0.42$
 $LL = 300 \times 1.7 = 0.51$
 $\left. \begin{array}{l} \\ \\ \end{array} \right\} = 0.93 \text{ k/ft}$

$M_u = 0.93 \times 6.55^2 / 8 = 5 \text{ k/ft}$

$d = 24 - 3 - 1 = 20 \text{ in } F = 0.40$

$A_{smin} = 0.0033 \times 240 = 0.8 \text{ in}^2$
 #8 @ 12 Both. TRANS.

VALUE PADS:

$A = 16 - 1 \left. \begin{array}{l} \\ \\ \end{array} \right\} = 15.1''$
 1.0 $m = \frac{A}{B} = 0.82$

$B = 19 - 5 \left. \begin{array}{l} \\ \\ \end{array} \right\} = 18.5''$
 1.0

$w = 12'' \text{ slab} = 150 \text{ psf} \times 1.4 = 210 \text{ psf}$
 $LL \text{ (No truck)} = 150 \text{ psf} \times 1.7 = 255 \text{ psf}$
 $w = 300 \text{ psf} \quad w_u = 465 \text{ psf}$

$M_{uA} = 0.0516 \times 0.465 \times 15.08^2 = 6 \text{ k/ft} \quad K_n = 94$

$M_{uB} = 0.023 \times 0.465 \times 18.42^2 = 3.6 \text{ k/ft}$

$d_A = 12 - 3 - 1 = 8'' \quad F = 0.064 \quad P_{um} = 0.0033$

$d_B = 12 - 4 - 1 = 7'' \quad F = 0.049 \quad A_{smin} = 0.31 \text{ in}^2$
 #5 @ 12 Both. EW.
 #5 @ 8 Top & W

$V_A = 0.465 \times 0.71 \times 15.08 = 2.49 \text{ k/ft (max)}$

Gr. Wall Loads: platform = $2.49 / 1.55 = 1.61 \text{ k/ft}$
 12" wall $2.5 \times 0.150 = 0.38$

1.99 k/ft

Brq pressure: $1.99 \text{ ksf} < 3.0 \text{ ksf allow.}$



CITY OF HOUSTON		3904-02	
PROJECT	Lift Station w/ Vaults		JOB NO. 0101
SUBJECT 3 Wet + 2 Dry Pumps.		14	
SHEET		DATE	
NMP DESIGNED	1-18-95	CHECKED	DATE

NOTE: Wetwell top slab similar to Lift str. w/o Valve Vault.

VALVE VAULT

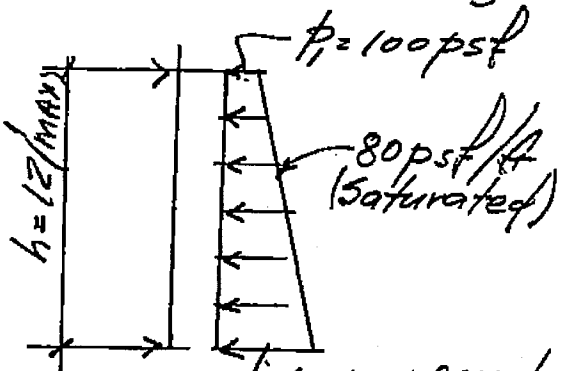
Top slab: Assume 24" thick slab:
 Loads = 24" slab = 300 psf } x 1.4 = 525
 Hatch @ 30 x 25 = 75' ² }
 LL: @ 300 psf = 300 x 1.7 = 510
 L = 21.9" $W_u = 1035 \text{ psf}$
 $M_u = 1.04 \times 21.75^2 / 8 = 61.5 \text{ k/ft}$
 $V_u = 1.04 \times \left(\frac{21.75}{2} - 1.75 \right) = 9.5 \text{ k/ft}$
 $K_n = 139 \quad \rho = 0.0027$
 $\rho_{min} = 0.0033$

Smaller Vault

L = 17.10"
 $M_u = 1.04 \times 17.83^2 / 8 = 41.3 \text{ k/ft}$
 $V_u = 1.04 \times \left(\frac{17.83}{2} - 1.75 \right) = 7.5 \text{ k/ft}$
 $\phi V_c = 27.7 \text{ k/ft}$
 Use $\rho_{min} = 0.0033 \quad A_g = 0.83 \text{ in}^2$

WALLS:

$T_{max} = \left. \begin{matrix} 11'-0" \\ 11'-0" \end{matrix} \right\} = 12'-0" \quad t = 12" \quad d = 12 - 2 \times \frac{1}{2} = 9"$



$\rho_1 / \rho_2 = \frac{100}{1060} = 0.10 \quad F = 0.081$
 $Q = \frac{(100 + 1060) \times 12'}{2} = 6.96 \text{ k}$
 $R_{bot} = 0.65 \times 6.96, \quad R_{top} = 0.35 \times 6.96$
 $R_{bot} = 4.52 \text{ k}, \quad R_{top} = 2.44 \text{ k/ft}$
 $M_{max} = \frac{6.96 \times 12}{7.82} = 10.7 \text{ k/ft}$

$\rho_2 = 100 + 80 \times 12' = 1060 \text{ psf}$
 $K_n = 225 \quad \rho = 0.0043 \quad A_g = 0.46 \text{ in}^2$
 $M_u = 1.7 \times 10.7 = 18.2 \text{ k/ft}$
 $V_u = 1.7 \times 4.52 = 7.68 \text{ k/ft}$
 $\phi V_c = 0.85 \times 2 \sqrt{4000} \times 9 \times 12 = 11.6 \text{ k/ft}$



PROJECT CITY OF HOUSTON		3904.00	
SUBJECT Lift Station w/Vaults 3 Wet + 2 Dry Pumps		JOB NO. 0101	
DESIGNED NMP	DATE 1-18-95	CHECKED	DATE
		15 SHEET	

BASE SLAB:

Loads: Top slab DL 300 psf
LL 300 psf

Walls 22.75'
20.50'
20.50'

$$\frac{63.75 \times 11 \times 0.150}{20.5 \times 22.75} = \frac{105.2k}{466.875} = 225 \text{ psf}$$

Consider Water Table to be up to Finished Grade
Des. Engr - Verify for 100 year flood level, if Critical.

$h_w = 1'-0" \left\{ \begin{array}{l} 11'-0" \\ 1'-6" \end{array} \right\} = 13'-6" \text{ 2plift} = 62.4 \times 13.5 = 842 \text{ psf}$

DL: 24" Top slab = 300
1/2" walls = 225
1'-6" Base slab = 225

750 psf

Backfill wt on footing, say 1'-0" wide.

$65.75' \times 1' \times 12' \times 0.06 = 47.3k$

$W_{eq} = \frac{47.3}{20.5 \times 22.75} = 100 \text{ psf}$

$\Sigma W_{DL} = 850 \text{ psf} \times 2 \text{ plift} = 842 \text{ psf}$

Soil pressure = DL = 850

LL = 300

1150 psf << 3000 psf min. allow soil bearing.
Des. Engr - Verify.

W = 300 Top slab $\times 1.4 = 420$
300 LL $\times 1.7 = 510$
225 walls $\times 1.4 = 315$
100 soil wt $\times 1.4 = 140$

$W = 925 \text{ psf}$

$W_u = 1385 \text{ psf}$

t = 18" base slab
d = 18-2-1 = 15" F = 0.225

$M_u = 1.385 \times \frac{21.75^2}{8} = 81.9 \text{ k/ft}$ $V_m = 364, \rho = 0.0072$

$V_u = 1.385 \left(\frac{21.75}{2} - 1.25 \right) = 13.3 \text{ k/ft}$ $\phi V_c = 0.85 \times 2 \sqrt{4000} \times 12 \times 15 = 19.35 \text{ k/ft}$

$A_s = 1.295 \text{ in}^2/\text{ft}$ # 8 @ 8" Top



CITY OF HOUSTON		390400
PROJECT	Lift Station w/ Vaults	JOB NO. 0101
SUBJECT	3 Wet + 2 dry Pumps	16
		SHEET
NMP	1-18-95	
DESIGNED	DATE	CHECKED
		DATE

Consider Base Slab as Two-way
 $a \approx b = 21.75'$ $m = 1.00$ Hinged all sides.
 $m^+ = 0.036 \times 139 \times 21.75^2 = 23.7 \text{ k/ft}$
 $K_n = 105$ $P_{min} = 0.0033$ $A_3 = 0.59 \text{ in}^2$ -
 # 7 @ 12 T. EW
 # 5 @ 12 Bot. EW.

Assume F.S. against uplift = 1.20

Net uplift = $(1.2 \times 842 - 850) = 160 \text{ psf}$

a. Consider base slab to resist by cantilever off the wetwell shaft

$M_u = 1.7 \times 0.160 \times 22.5^2 = 68.9 \text{ k/ft}$

$F = 0.225$, $K_n = 306$ $P = 0.006$

$A_3 = 1.08 \text{ in}^2$ # 8 @ 8" dets.

b. Consider net uplift shared by Top slab and base slab equally

$M_u = 34.5 \text{ k/ft}$

$K_n = 153$ $P_{min} = 0.0033$

$A_3 = 0.59 \text{ in}^2/\text{ft}$

7 @ 12 Bot. Dets from wetwell wall.

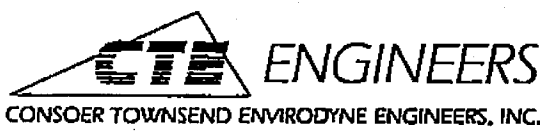
Use this

c. Increase wall thickness $t_w = 16"$ base slab $t = 2'0"$ and base slab projection $2'0"$.

$t_w = \left. \begin{matrix} 2'0 \\ 11'0 \\ 2'0 \end{matrix} \right\} = 15'$ uplift = $62.4 \times 15 = 936 \text{ psf}$

DL: Top slab = 300 psf
 Base slab = 300 "

walls = $\left. \begin{matrix} 20.50 \\ 20.50 \\ 23.42 \end{matrix} \right\} = 64.42' \times 11 \times 1.33 \times 150 = \frac{141.4 \text{ k}}{20.5 \times 23.42} = 294 \text{ psf}$



CITY OF Houston		3904.00
PROJECT		JOB NO 0101
Lift Station w/ Vaults		17
SUBJECT	3 Wet + 2 Dry Pumps	SHEET
NMP	1-19-95	
DESIGNED	DATE	CHECKED
		DATE

Soil wt: 20.50
 20.50
 27.42

$$\frac{68.42}{20.50} \times 14. \times 2.0 \times 60 = \frac{115.6}{20.50 \times 23.42} = 239 \text{ psf}$$

$\Sigma DL =$ Top slab = 300 psf
 Base slab = 300
 walls = 294
 Soil = 239

$$\frac{1133}{936} = 1.21$$

Small Valve Vault:

hw = 24" 24" lift = 10.17' x 62.4 = 635 psf ↑
 6'-8"
 1'-6"

$$\frac{10'-2"}{12} \times 12.50 = 10.17'$$

DL: 24" Top slab = 300 psf
 12" walls 12.50
 12.50

$$\frac{18.83}{12.5 \times 18.83} \times 6.67 \times 150 = \frac{43.85}{12.5 \times 18.83} = 186 \text{ psf}$$

18" Base slab = 225 psf
 $\Sigma DL = 711 \text{ psf}$ F.S. = $\frac{711}{635} = 1.12$

Assume 1'-0" Base slab extension:

Wt of Soil: 12.50
 12.50
 20.83

$$\frac{45.83}{12.5 \times 18.83} \times 9.17 \times 10 \times 60 = \frac{25.2}{12.5 \times 18.83} = 107 \text{ psf}$$

$\Sigma DL = 818 \text{ psf}$ F.S. = $\frac{818}{635} = 1.29 > 1.20$



CITY OF HOUSTON		3904-00	
PROJECT		JOB NO. 0101	
Lift Station w/ Vaults		18	
SUBJECT Wet + 2 dry Pumps		SHEET	
NMP	1-19-95	CHECKED	DATE
DESIGNED	DATE	CHECKED	DATE

Base Slab

Loads: Top slab = 300 psf
 Walls = 186 " } x 1.4 = 830
 Soil = 107 " }
 LL. Top slab = 300 psf x 1.7 = 510
 W = 893 psf W_L = 1340 psf

Consider Two-way slab, hinged all edges.

A = 13'-6"
 B = 17'-10" m = 0.76

$M_{UA}^+ = 0.061 \times 1.34 \times 13.5^2 = 14.9 \text{ k/ft}$ $K_m = 88$

$M_{UB}^+ = 0.019 \times 1.34 \times 17.83^2 = 8.1 \text{ k/ft}$

$d = 16 - 2 - 1 = 13''$ $F = 0.169$

$f_{min} = 0.0033$ $A_3 = 0.51 \text{ in}^2$

#5 @ 8" EW (0.47)
#5 @ 12" Bot EW



HOUSTON, TX 5705		3921-00
PROJECT LP, SSC, Pump STA-HZ		JOB NO. 0101
SUBJECT 4 WET & 2 DRY WEATHER PUMPS		1 OF 9 SHEET
NMP DESIGNED	12-7-95	DATE
CHECKED		DATE

VALVE PIT NO. 1: 21'-2" x 30'-9" x 13'-0" walls $t = 24"$
 Grating FRP $wt = 25 \text{ pcf}$
 LIVE LOAD = 150 pcf
 $w = 175 \text{ pcf}$

Support Beams:

Beam B1: $l = 29'-5"$
 $\quad \quad \quad - 2'-8"$
 $\quad \quad \quad \underline{\quad \quad \quad}$
 $\quad \quad \quad 26'-9"$

$w = 175 \left(\frac{3.17 + 5.0}{2} \right) = 715 \text{ plf}$
 Bm wt = 35

$M = 0.75 \times 26.75^2 / 8 = 67.0 \text{ k}$
 $V = 10.0 \text{ k}$
 $W = 20.0 \text{ k}$

W12X35 $l_u = 14' \pm$
 $M_R = 75 \text{ k}$

3-3/4" ϕ Single- $\frac{1}{2}$ shear connect.
10M

$\Delta = \frac{5 \times 20 \times (26.75 \times 12)^3}{384 \times 29 \times 10^3 \times 285} = 1.104" = \frac{l}{308}$

$\frac{I_f = 66"}{30}$
 $\frac{36 \pm \rightarrow 38"}{}$

Beam B2: $l = 26'-9"$

$w = 175 \times \left(\frac{5.0 + 5.5}{2} \right) = 920 \text{ plf}$
 Bm. wt = 40
 960 plf

$M = 0.96 \times 26.75^2 / 8 = 85.9 \text{ k}$
 $V = 0.96 \times 26.75 / 2 = 12.84 \text{ k}$
 $W = 25.68 \text{ k}$

W12X40 $l_u = 14' \pm$

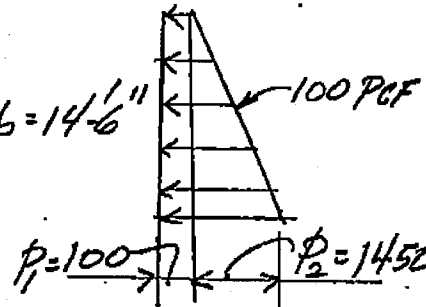
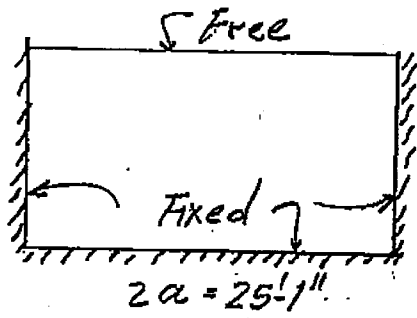
3-3/4" ϕ Single $\frac{1}{2}$ shear Conn.
 $M_R = 95 \text{ k}$
 $R = 16.3 \text{ k} > V = 12.84 \text{ k}$

$\Delta = \frac{5 \times 25.68 \times (26.75 \times 12)^3}{384 \times 29 \times 10^3 \times 310}$
 $= 1.23" = \frac{l}{261} < \frac{l}{240}$



HOUSTON, TX STDS		3921-00	
PROJECT		JOB NO. 0101	
4 WET & 2 DRY WEATH. PCIMPS		2 OF 9	
SUBJECT		SHEET	
NMP	12-7-95	CHECKED	DATE
DESIGNED	DATE 5-3-96		

VALUE PIT WALLS:



$$a/b = \frac{25.08}{2 \times 14.5} = 0.86 < \begin{matrix} 0.75 \\ 0.88 \\ 1.00 \end{matrix}$$

$$\begin{aligned} P_1 b &= 1.5 \\ P_1 b^2 &= 21.0 \\ P_2 b &= 21.0 \\ P_2 b^2 &= 305.0 \end{aligned}$$

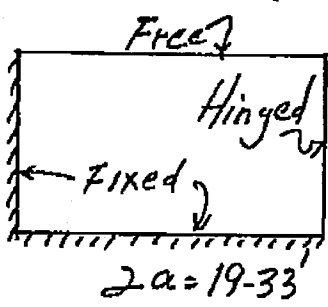
$$\begin{aligned} M_x^- &= 0.2205 \times 21 + 0.0525 \times 305 = 20.6 \text{ k/ft} & M_x^+ &= 35.1 \text{ k/ft} \\ M_x^+ &= 0.0908 \times 21 + 0.0245 \times 305 = 9.4 & &= 16.0 \\ M_y^- &= 0.1628 \times 21 + 0.0715 \times 305 = 25.2 & &= 42.9 \\ M_y^+ &= 0.0242 \times 21 + 0.0149 \times 305 = 5.1 & &= 8.6 \text{ k/ft} \end{aligned}$$

$$\begin{aligned} t &= 24'' & d_H &= 20.0'' & F_H &= 0.40 \\ & & d_V &= 21.0'' & F_V &= 0.44 \end{aligned}$$

$$\begin{aligned} K_{mx}^- &= 88. & \rho &= 0.0016 \times 1.33 = 0.0021 & A_{3H}^- &= 0.50 \text{ in}^2 & \text{Hori. @ Corn. \#6 @ 14''} \\ K_{mx}^+ &= 40. & \rho &= 0.0013 \times 1.33 = 0.0017 & A_{3H}^+ &= 0.40 & \text{6 @ 14 HEF} \\ K_{ny}^- &= 98. & \rho &= 0.0018 \times 1.33 = 0.0024 & A_{3V}^- &= 0.60 & \text{\#6 @ 7 V OF DWLS.} \\ K_{ny}^+ &= 20. & \rho &= 0.0013 \times 1.33 = 0.0017 & A_{3V}^+ &= 0.42 \text{ in}^2 & \text{\#6 @ 14 VEF} \end{aligned}$$

$$\begin{aligned} V_{y \max} &= 0.7588 \times 1.5 + 0.4320 \times 21 = 10.2 \text{ k/ft} \\ V_y &= 10.2 - 1.5 \times 1.13 = 8.51 \text{ k/ft} & V_u &= 14.47 \text{ k/ft} \\ \phi V_c &= 2 \times 0.85 \sqrt{4000} \times 12 \times 21.0 = 27.10 \text{ k/ft} > V_{u \max} = 14.47 \text{ k/ft} \end{aligned}$$

SIDE WALLS:



Consider hinged Vertical Edges.

$$\begin{aligned} a/b &= \frac{19.33}{2 \times 14.5} = 0.67 \approx 0.75 \\ m_x^+ &= 0.1217 \times 21 + 0.337 \times 305 = 12.8 \text{ k/ft} & M_{ux}^+ &= 21.8 \text{ k/ft} \\ m_x^- &= 0.2136 \times 21 + 0.087 \times 305 = 31.05 & &= 52.8 \\ m_y^+ &= 0.0304 \times 21 + 0.0168 \times 305 = 5.8 & &= 9.8 \\ K_{nx}^- &= 55 & \rho &= 0.0013 \times 1.33 = 0.0017 & A_{3H}^- &= 0.40 & \text{\#6 @ 14} \\ K_{ny}^- &= 120 & \rho &= 0.0023 \times 1.33 = 0.0030 & A_{3V}^- &= 0.76 & \text{\#6 @ 7} \\ K_{ny}^+ &= 22 & \rho &= 0.0013 \times 1.33 = 0.0017 & A_{3V}^+ &= 0.42 & \text{\#6 @ 14} \end{aligned}$$



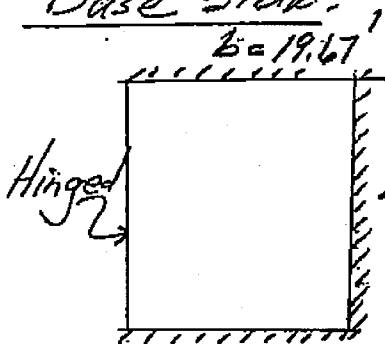
HOUSTON, TX, STDS		3921
PROJECT		JOB NO.
4 WET & 2 DRY WEATHER PUMPS		3 OF 9
SUBJECT		SHEET
NMP	12-8-95	
DESIGNED	DATE	CHECKED
		DATE

Buoyancy check: Consider structure right of Exp. Jt.

DEAD LOADS: 24" Walls: $2 \times 20.66 \times 13 \times 2 \times 0.150 = 161.2^k$
 $1 \times 26.75 \times 13 \times 2 \times 0.150 = 104.3$
 2'-6" Base slab: $24.67 \times 38.75 \times 2.5 \times 0.150 = 358.5^k$
 4'-0" of soil wt: $2 \times 24.67 \times 12.5 \times 4 \times 0.120 = 296.0$ $W_c = 624.0^k$
 $1 \times 30.75 \times 12.5 \times 4 \times 0.120 = 184.5$
 $2 \text{ up lift} = 24.67 \times 38.75 \times 15.5 \times 0.062 = 74.8^k$ $W_s = 480.5^k$ $\Sigma W = 1104.5^k$
 $\frac{624}{1.10} + \frac{480.5}{1.50} = 567.3 + 320.3 = 887.6^k < F_u$ $F_s = \frac{1104.5}{918.7}$
 $\Delta W = -33.1^k$ $= 1.20$

NOTE: see sht. 69a for additional calculations for Buoyancy check.

Base slab:



Net up lift = $0.062 \times 15.5 = 0.967 \uparrow$
 $- 2.50 \times 0.150 = 0.375 \downarrow$
 $p = 0.592 \uparrow \text{ ksf}$

$a/b = 28.75 / 19.67 = 1.46$
 $\phi b = 11.6$
 $\phi b^2 = 229$

$a/b = \frac{28.75}{2 \times 19.67} = 0.73 \approx 0.75$

$M_x^- = 0.0695 \times 229 = 15.9^k/ft$ $M_{max}^- = 27.0^k/ft$ $K_{max}^- = 42$

$M_x^+ = 0.0274 \times 229 = 6.3^k/ft$ $= 10.7$

$M_y^- = 0.0898 \times 229 = 20.6^k/ft$ $= 35.0$ $K_{max} = 54$

$M_y^+ = 0.0473 \times 229 = 10.8^k/ft$ $M_{max}^+ = 18.4^k/ft$

$t = 30''$ $d_T = d_B = 30'' - 3'' - \frac{1}{2}'' - 1'' = 25.5''$ $f = 0.650$

$\rho_{min} = 0.0018$ $A_{s,min} = 0.0018 \times 12 \times 30 = 0.65 \text{ in}^2/ft$

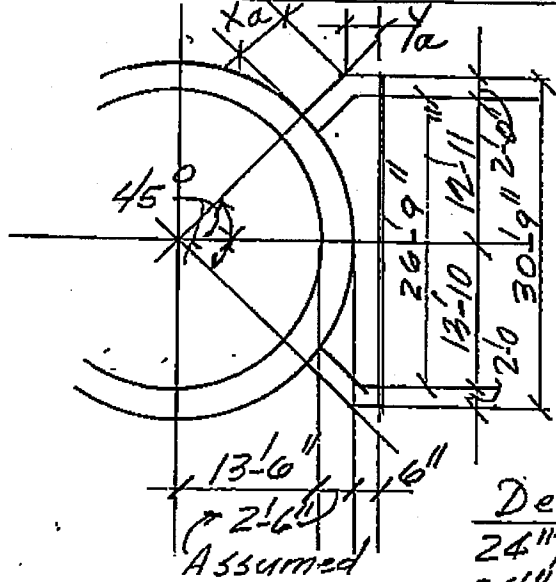
$V_{hinge,max} = 0.3874 \times 11.4 = 4.42^k/ft$ $\# 6 @ 8'' \text{ TEW}$
 $V_u = 7.50^k/ft < \phi V_c = 25.85^k$ (Wall d w/ 15) $\# 6 @ 12 \text{ BEW}$ w/ $\# 6 @ 7''$



Houston, Tx Stds		3921-	
PROJECT		JOB NO. 0101	
4 Wet + 2 Dry weather Pumps		3a of 10	
SUBJECT		SHEET	
NMP	5-1-96		
DESIGNED	DATE	CHECKED	DATE

Buoyancy check: Cont.

Consider structure between Exp. Joint and wet well:



$$x_a = \frac{30.75}{2 \times 0.707} - 16.0 = 4.02'$$

$$y_a = 16.5 - 15.38 = 1.12'$$

ave. wall $l = 5.14$ ft.

Top slab area = $1.12 \times 30.75 = 34.4$
 $15.38 \times 15.38 = 236.5$
 $-\pi \times 16^2 / 4 = -201.0$

Base slab area: $70. + 2 \times 5.14 \times 4' = 111.1$ ft²

Dead loads

24" top slab: $70 \times 2 \times 0.150 = 21.0$ k

24" walls: $2 \times 5.14 \times 11' \times 2 \times 0.150 = 33.9$

30" Base slab: $111.1 \times 2.5 \times 0.150 = 41.7$

Soil wt: $2 \times 4' \times 5.14 \times 12.5 \times 0.120 = 61.7$ k $w_c = 96.6$ k

Uplift: $111.1 \times 15.5 \times 0.062 = 106.8$ k

$(624 + 96.6) + (480.5 + 61.7)$
 $\frac{1.10}{1.50}$

$655 + 361.5 = 1016.5$ k $F_u = 1025.5$

$\Sigma W_c = 720.6$

$\Sigma W_s = 542.2$

$\Sigma W = 1262.8$ k

$\Sigma F_u = 1025.5$ k

$\Delta W = -9.0$ k.

$FS = 1.23$.

NOTE: 1. To conform w/ COH Des. MNL floatation F.S., the Dead wt. is short by 9.0 kips. Insignificant.



HOUSTON, TX STDS		3921-00	
PROJECT		JOB NO 0101	
4 Wet + 2 Dry Weather Pumps 4 of 9		SHEET	
NMP	12-8-95	CHECKED	DATE
DESIGNED			

REF: PCI, Design Hand Book: 4th Ed. Table 6.20.8

NOTE: This Table can be used to evaluate Shear capacity of 1" DIA. dowel bar in Expansion joint TYPE-E3. 1" Dia at 12" c in walls and base slab.

I Shear Capacity in Wall:

$$\phi V_c = 25.85 \text{ k/Dowel For } n=1$$

$f'_c = 4000 \text{ psi}$ $f_{sy} = 60,000 \text{ psi}$
 $d_b = 7" \phi$ (8" for Corrosion Loss)

or $\phi V_c = \phi V'_c C_w C_t C_c$ where $\phi V'_c = 27.94 \text{ k}$, for $d_c = 12"$

$C_w = 1.0$ $b = 0$
 $C_t = 1.0$, $h >> 1.3 d_c$
 $C_c = 0.87$ $d_c = 8"$

$= 24.2 \text{ k} \leftarrow \text{Controls}$

$\phi V_s = 27.1 \text{ k}$

II Shear Capacity in Base Slab:

$\phi V_c = 25.85 \text{ k} \leftarrow \text{Controls}$

or $\phi V_c = \phi V'_c C_w C_t C_c$ where $\phi V'_c = 27.94 \text{ k}$; $d_c = 14"$

$C_w = 1.0$, $n_s = 1$
 $C_t = 1.0$ $h >> 1.3 d_c$
 $C_c = 1.0$ $d_c > d_e$

$= 27.94 \text{ k}$

$\phi V_s = 27.1 \text{ k}$

Wall dowels = 1" ϕ @ 12"

$V_w = 11.24 \text{ k}$

$M = 11.24 \times 0.5 = 5.62 \text{ k}$

10982

$f_y = \frac{11.24 \times 60}{27.1} = 24.88 \text{ ksi}$

$f_{st} = \frac{5.62}{0.7854 \times 0.53} = 57.24 \text{ ksi}$

$f_s = \sqrt{57.24^2 + 24.88^2} = 62.4 \text{ ksi}$

Note: Walls will not get full uplift reaction. Base slab will take some.



PROJECT		Houston Tx, 57DS	
SUBJECT		4 Wet + 2 Dry weather pumps	
DESIGNED	DATE	CHECKED	DATE
NMP	12-8-95		

3921-00
JOB NO 0101
5 OF 9
SHEET

Wall bracket from wet well: 9.3-96

Ref: PCA "Simplified Design" shear walls, pg 6-13.

$$\phi M_n = \phi \left[0.5 A_{st} f_y l_w \left(1 + \frac{P_u}{A_{st} f_y} \right) \left(1 - \frac{c}{l_w} \right) \right]$$

where $\phi = 0.90$

$$A_{st} = \#6 @ 12 \text{ HEF} = 0.44 \times 2 \times 13 = 11.44 \text{ in}^2$$

$$l_w = 13' = 156" \quad h = 24" \text{ wall thickness}$$

$P_u = 0$ across joint

$$\omega = \frac{A_{st} f_y}{l_w h f_c'} = \frac{11.44 \times 60}{156 \times 24 \times 4} = 0.046$$

$$\frac{c}{l_w} = \frac{\omega}{2\omega + 0.85\beta_1} \quad \beta_1 = 0.85 \text{ for } f_c' = 4000$$

$$= \frac{0.046}{0.092 + 0.722} = 0.057$$

$$\phi M_n = \frac{0.90}{12} [0.5 \times 11.44 \times 60 \times 156 (0.94)] = 3787 \text{ k}$$

Assume wet well wall 2'-0" thick (min).

$$R_0 = 13.5 + 2.1 = 15.50'$$

$$L = \text{Cantilever} = \sqrt{15.5^2 + 15.17^2} - 15.50 = 6.19'$$

$$M_u = 1.7 \times 86 \times 6.19 = 905 \text{ k} < 3787 \text{ k}$$

Base slab bracket from wet well wall:

$$L_{\text{max}} = 6.19 \cos 45^\circ = 4.38'$$

$$M_{u \text{ max}} = 7.5 \times 4.38 = 32.8 \text{ k/ft}$$

$$t = 2'-4" = 28"$$

$$P_{\text{min}} = 0.0018$$

$$k_m = 8.2$$

$$d = 20" \quad F = 0.400$$

$$A_s = 0.0018 \times 20 \times 12 = 0.43 \text{ in}^2/\text{ft} \quad \#6 @ 12" \text{ provided.}$$



HOUSTON, TX, STD5		3921-00
PROJECT LP. SSC PUMP STN. H2		JOB NO. 0101
SUBJECT 4 wet + 2 Dry Weather Pumps		6 OF 9 SHEET
NMP DESIGNED	12-11-95 DATE	CHECKED DATE

VALUE PIT NO. 2: 14'-0" x 18'-10" x 8'-8" walls 1'-0" thick

Grating FRP wt. = 25 psf
 Live Load = 150 psf
 $w = 175 \text{ psf}$

Support beam:

$$w = 175 \left(\frac{4.33 + 2.25}{2} \right) = 575 \text{ plf}$$

$$\text{Pm wt} = \frac{25}{600} \text{ plf}$$

$$l = 16'-10"$$

$$M = 0.6 \times 16.83^2 / 8 = 21.2 \text{ k}$$

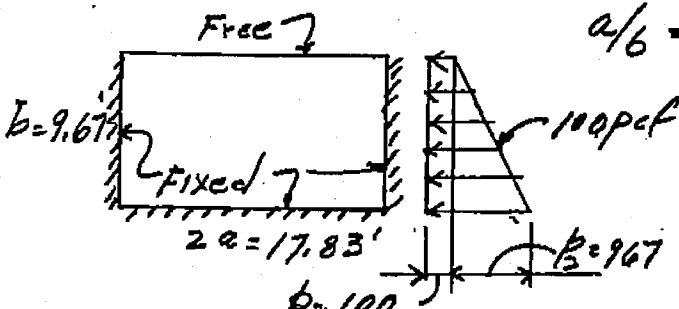
$$V = 0.6 \times 8.42 = 5.05 \text{ k}$$

$$W = 10.1 \text{ k}$$

W8X24 $l_n = 16.83'$
 $M_R = 33.5 \text{ k}$
 21se w/ 2-34" ϕ single
 3/8" Conn. w/ 5/16" weld
 $R = 8.2 \text{ k}$

$$\Delta = \frac{0.89 \times 10.1}{19} = 0.47" = \frac{1}{426}$$

End Wall: Ref: 215 Bureau of Reclamation, EM No. 27.



$$a/b = \frac{17.83}{2 \times 9.67} = 0.92 \approx 1.00$$

$$p_1 b = 100$$

$$p_1 b^2 = 9.4$$

$$p_2 b = 96.7$$

$$p_2 b^2 = 90.4$$

$$M_x^- = 0.2613 \times 9.4 + 0.0644 \times 90.4 = 8.3 \text{ k/ft}$$

$$M_x^+ = 0.1008 \times 9.4 + 0.0276 \times 90.4 = 3.4$$

$$M_y^- = 0.2043 \times 9.4 + 0.0845 \times 90.4 = 9.6$$

$$M_y^+ = 0.0243 \times 9.4 + 0.0159 \times 90.4 = 1.7$$

$$M_u = 14.1 \text{ k/ft}$$

$$= 5.9 \text{ k/ft}$$

$$= 16.3$$

$$= 2.8$$

$$t = 12" \quad d_v = 9.5" \quad F_v = 0.09$$

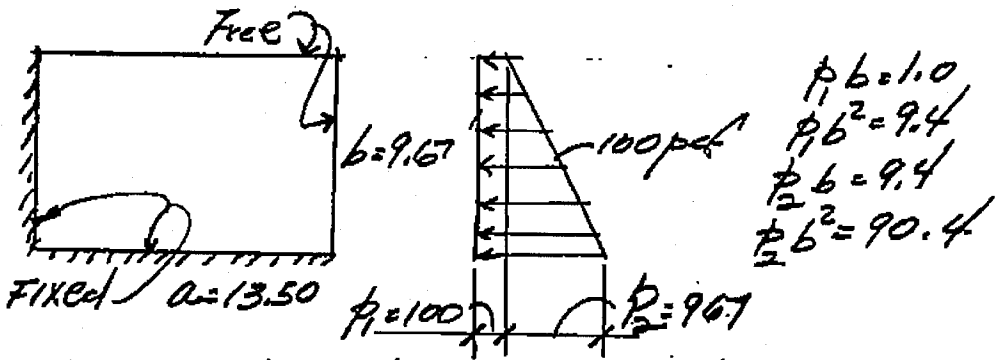
$$d_h = 8.5" \quad F_h = 0.07$$



HOUSTON TX STDS		3921-00
PROJECT LP, SSC Pump Stn, HZ		JOB NO. 0101
SUBJECT AWet + 2 Dry weather Pumps		7 of 9 SHEET
NMP DESIGNED	12-14-95 DATE	CHECKED DATE

$K_{mx}^- = 201$ $P = 0.0039$ $A_3^- = 0.0039 \times 12 \times 85 = 0.40 \text{ in}^2/\text{ft}$ #5 @ 6" H
 $K_{my}^+ = 84$ $P_{min} = 0.0018$ $A_3^+ = 0.0018 \times 12 \times 12 = 0.26$ #5 @ 12" H
 $K_{my}^- = 181$ $P = 0.0035$ $A_3^- = 0.0035 \times 12 \times 9.5 = 0.40$ #5 @ 6" DWL
 $K_{my}^+ = 31$ $P_{min} = 0.0018$ $= 0.26$ #5 @ 12" VEF

Pat Side walls: $a/b = 13.5/9.67 = 1.4 \approx 1.00$



$M_x^- = 0.2949 \times 9.4 + 0.0662 \times 90.4 = 8.8 \text{ k/ft}$ $M_{ux} = 14.9 \text{ k/ft}$
 $M_x^+ = 0.0324 \times 9.4 + 0.0077 \times 90.4 = 1.0$ $= 1.7 \text{ k/ft}$
 $M_y^- = 0.2949 \times 9.4 + 0.1157 \times 90.4 = 13.2$ $= 22.5$
 $M_y^+ = 0.0324 \times 9.4 + 0.0172 \times 90.4 = 1.9$ $= 3.2$

$K_{mx}^- = 213$ $P = 0.0041$ $A_3^- = 0.42 \text{ in}^2$ #5 @ 6" Corner
 $K_{mx}^+ = 24$ $P_{min} = 0.0018$ $A_3^+ = 0.26 \text{ in}^2/\text{ft}$ #5 @ 12" HEF.
 $K_{my}^- = 250$ $P = 0.0049$ $A_3^- = 0.56 \text{ in}^2/\text{ft}$ #5 @ 6" dwls of.
 $K_{my}^+ = 36$ $P_{min} = 0.0018$ $A_3^+ = 0.26 \text{ in}^2/\text{ft}$ #5 @ 12" VEF.

Buoyancy check:

Dead loads: Walls: $2 \times 14 \times 8.67 \times 0.150 = 36.4 \text{ k}$
 Base slab: $1 \times 16.83 \times 8.67 \times 0.150 = 21.9$
 Soil: $14 \times 18.83 \times 1.33 \times 0.150 = 52.6$
 $2 \times 1.0 \times 15.0 \times 8.67 \times 0.06 = 15.6$
 $1 \times 1.0 \times 18.83 \times 8.67 \times 0.06 = 9.8$
 $2 \uparrow \text{lift Force} = 18.83 \times 14 \times 10 \times 0.062 = 164.5 \text{ k}$
 $\Delta W_{DL} = 1.25 \times 164.5 - 136.3 = 69.3 \text{ k}$



Houston, Tx STDS		3921-00
PROJECT LP 350 Pump Stn - HZ	JOB NO. 0101	
SUBJECT 4 Wet + 2 Dry Weather Pumps		8 OF 9
SHEET		
NMP	12-14-95	
DESIGNED	DATE	CHECKED
		DATE

Consider ΔW_{DL} is available from wet well DL. Shear transfer to wet well thru two wall brackets

$$V_u \text{ per wall} = 69.3/2 = 34.65 \text{ k}$$

$$V_u = 1.7 \times 34.65 = 58.9 \text{ k (up lift)}$$

Wall bracket:

Assume wet-well wall $t = 2'-0$ min.

$$\begin{array}{r}
 x = 13'-6 \\
 \quad 2'-0 \\
 \hline
 \quad 0'-6 \\
 \hline
 16'-0
 \end{array}
 \qquad
 \begin{array}{r}
 y = 9'-5 \\
 \quad - 0'-6 \\
 \hline
 \quad 8'-11
 \end{array}$$

$$L = \sqrt{16^2 + 8.92^2} - 15.50' = 2.82 \text{ ft}$$

$$M_u = 58.9 \times 2.82 = 166 \text{ k-ft}$$

Ref: PCA, "Simplified Design" shear walls, pg 6-13.

$$\phi M_u = \phi [0.5 A_{z1} f_y l_w (1 + \frac{P_u}{A_s f_y}) (1 - \frac{c}{l_w})]$$

where $P_u = 0$

$$A_{z1} = \#5 @ 12 = 0.31 \times 2 \times 8' = 4.96 \text{ in}^2$$

$$l_w = 8.67' = 104" \quad h = 12"$$

$$w = \frac{A_{z1} \times f_y}{l_w h f_c} = \frac{4.96}{104 \times 12} \times \frac{60}{4} = 0.0596$$

$$\frac{c}{l_w} = \frac{w}{2w + 0.85 \beta_1} \quad \beta_1 = 0.85 \text{ for } f_c' = 4000$$

$$= \frac{0.0596}{0.1192 + 0.7225} = 0.071$$

$$\phi M_u = \frac{0.90 \times 0.5 \times 4.96 \times 60 \times 104 \times 0.929}{12} = 1078 \text{ k-ft}$$

$$V_u = 58.9 \text{ k} / 8' = 7.37 \text{ k/ft} \text{ or per } 1' \phi \times 2'-0 \text{ d/wl.} \quad \gg M_u = 166$$

$$\phi V_c = 24.2 \text{ k/dwl (Controls)} > V_u = 7.37 \text{ k/dwl.}$$

(See shk. 3 of



HOUSTON, TX STDS		3921-00
PROJECT	LP, SSC Pump Str. HZ	JOB NO 0101
SUBJECT		9 of 9
4 Wet + 2 Dry weather Pumps		SHEET
DESIGNED	DATE	CHECKED
NMP	12-14-95	DATE

Consider Combined Bending and Shear of dowels:

$$M_u = V_u \times a = 0.50'' \times 7.37 = 3.69''k$$

$$f_{sb} = \frac{3.69}{0.7854 \times 0.5^3} = 37.59 \text{ ksi}$$

$$f_{su} = \frac{7.37 \times 60}{27.1} = 16.32 \text{ ksi}$$

$$f_c = \sqrt{37.59^2 + 16.32^2} = 40.98 \text{ ksi} < 60 \text{ ksi.}$$

II Shear Capacity of 1" ϕ x 20' dowel in base slab:

$$\phi V_c = 25.85 \text{ k/dwl.} \quad @ 12'' \text{ c/c.}$$

or $\phi V_c = \phi V_c' C_u C_f C_c$ where $\phi V_c' = 15.2 \text{ k}$ $d_e = 8''$

$C_u = 1$ $C_f = 1$ $C_c = 1$

$h > 1.3 d_e = 10.4''$

$d_c > d_e$

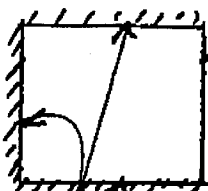
$$\phi V_c = 15.2 \text{ k/dwl.}$$

$$\phi V_s = 27.1 \text{ k/dwl.}$$

controls $\gg V_u = 4.66 \text{ k/ft or dwl.}$

Base Slab:

$$a/b = \frac{17.83}{2 \times 13.5} = 0.66$$



Hinged

$$2a = 17.83'$$

Fixed $b = 13.5'$

$$t = 16'' \quad d = 16 - 3 - 1/2 = 11.5'' \quad F = 0.132$$

Net Uplift = $10 \times 62.4 = 624$
 $- 1.33 \times 150 = -200 \text{ pcf}$
 $524 \text{ pcf} \uparrow$

$$p_b = 7.07$$

$$p_b^2 = 95.5$$

$$M_x^- = 0.0695 \times 95.5 = 6.64 \quad M_{ux} = 11.3 \text{ k/ft} \quad K_n = 86$$

$$M_x^+ = 0.0274 \times 95.5 = 2.62 \quad = 4.4 \quad = 33$$

$$M_y^- = 0.0898 \times 95.5 = 8.58 \quad = 14.6 \quad = 111 \quad R = 0.002$$

$$M_y^+ = 0.0473 \times 95.5 = 4.52 \quad = 7.7 \quad = 58 \quad A_s = 0.38 \text{ in}^2$$

$V_{\text{hinge, max}} = 0.3874 \times 7.07 = 2.74 \text{ k/ft}$ $V_u = 4.66 \text{ k/ft or } \#6 @ 12 \text{ TEW}$
 $\#5 @ 8 \text{ TEW}$



CITY OF HOUSTON, TX		3904-00	
PROJECT		JOB NO. 0101	
LIFT. STN. W/O VALVE VAULT		19	
SUBJECT	AWET & 2 DRY PUMPS	SHEET	
NMP	11-4-94	JAM	11-8-94
DESIGNED	DATE	CHECKED	DATE

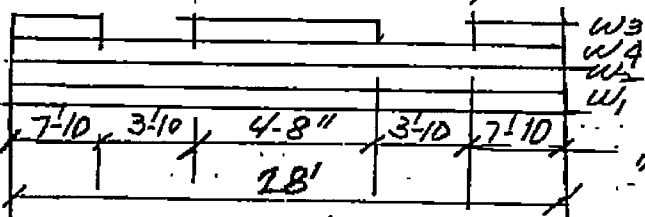
WET WELL: TOP SLAB:

(Sht. C34)

Consider 2'-0" thick slab.

Band Beam B1: $b = 3'-10" = 46"$
 (Between Hatches) $t = 24"$ $d = 21"$ $F = 1.689$
 $l = 27'-0"$ $v_{c/c} = 28'$ (1/6 of 1'-0" Brg ca. ends)

Loads; DL: $w_1 = 300 \times 3.83 = 1150 \text{ \#/ft}$
 $w_2 = 30 \times 4.75 = 150$
 $w_3 = 300 \times 2.75 = 825$
 LL: $w_4 = 300 \times 8.58 = 2575$



$2125 \times 1.7 = 4.38 \text{ k/ft}$
 $2125 \times 1.4 = 2.98 \text{ k/ft}$
 $\Sigma w_u = 7.36 \text{ k/ft}$

$w_1 \ 16.1 \times 1.4 = 22.54 \text{ k}$
 $w_2 \ 2.1 \times 1.4 = 2.94$
 $w_{3mid} \ 1.9 \times 1.4 = 2.69$
 $w_{3end} \ 6.46 \times 1.4 = 9.04$
 $w_4 \ 36.05 \times 1.7 = 61.29$

$M_u = 92.8 \times 13.5 = 1252.8 \text{ k}$
 $- 2.174 \times 6.75 = -146.7$
 $- 2.84 \times 6.75 = -19.2$
 $- 2.2 \times 1.17 = -2.6$
 $- 6.93 \times 9.83 = -68.2$
 $- 59.09 \times 6.75 = -398.9$
 617.2 k
 (L=27)

$V_{ud} = 98.50 - 7.36(0.50 + 1.75) = 81.94 \text{ k}$

$M_u = 98.50 \times 14 = 1379$
 $- 22.54 \times 7 = -158$
 $- 2.94 \times 7 = -20.0$
 $- 2.69 \times 1.17 = -3.0$
 $- 9.04 \times 10.08 = -91$
 $- 61.29 \times 7 = -429$

$K_n = 522 \ f = 0.107$

$A_s = 10.33 \text{ in}^2$

$13 \#8 \text{ Boff. @ } 3 \frac{1}{2}'' \text{ c/c}$
 (in 46" width w/ 2 1/2" Side Cover)
 $M_{ud} = 678 \text{ k}$
 $M_{ud} = 1.3 M_u = 881 \text{ k}$



CITY OF HOUSTON, TX		3904 00
PROJECT	JOB NO. 0101	
LIFT STN. W/O VALVE VAULT		
SUBJECT	4 WET + 2 DRY WTR PUM	0.20 SHEET
NMP DESIGNED	11-4-94 DATE	JAM CHECKED
		11-8-94 DATE

Beam NO 2: Between 4 Hatches and Discharge pipes.

$$L = \sqrt{13.5^2 - 4.81^2} \times 2 = 25.23 + 1.0 = 26.23' \text{ c/c}$$

$$I_2 = 8.44$$

$$\begin{array}{r} -1.00 - 24'' \phi \text{ pipe} \\ -4.81 \\ \hline 2.63 \text{ ft} = 31.5'' \text{ Say } 31'' \end{array}$$

Loads: DL: $300 \times 3.63' = 1089$ $F = 1.139$
 $30 \text{ p.s.f} \times 2.52 = 76$ $= 1089 \times 1.4 = 1.52$
 LL: $300 \times 6.15' = 1845$ $= 76 \times 1.4 = 0.11$
 $= 1845 \times 1.7 = 3.14$

$M_u = 4.77 \times 26.23^2 / 8 = 410 \text{ k-ft}$ $W_{DL+LL} = 3010 \text{ #/ft}$ $W_u = 4.77 \text{ k/ft}$

$M_{u, \text{les}} = 1.3 M_u = 533 \text{ k}$

$V_u = 4.77 (26.23 - 0.5 - 1.75) = 51.8 \text{ k}$

$K_n = 468$ $\rho = 0.0095$ $\phi V_c = 0.85 \times 2 \sqrt{4000} \times 31 \times 21 = 70 \text{ k}$

$A_s = 6.18 \text{ in}^2$ B #8 @ 33" c/c. Bot.

Beam B3: between Hatches:

$b = 1' 4 \frac{1}{2}''$ $t = 24''$ $d = 20''$

$W = DL = 300 \times 1.38' = 414$ $\times 1.4 = 580$

$30 \times 4.50' = 135$ $\times 1.4 = 189$

$LL = 300 \times 5.38' = 1614$ $\times 1.7 = 2744$

$L = 7' 0 \frac{1}{2}''$ $\frac{2163}{W_u} = 3513 \text{ p.l.f.}$

$M_u = 3.5 \times 7.104 / 8 = 22 \text{ k}$

$M_{u, \text{les}} = 1.3 M_u = 28 \text{ k}$

$\rho_{\text{min}} = 0.0033$ $A_s = 1.04 \text{ in}^2$ 2 #8 T & Bot.

$V_u = 12.3 \text{ k} < \phi V_c = 35.4 \text{ k}$



CITY OF HOUSTON, TX		3904.00	
PROJECT		JOB NO. 0101	
LIFT STN. W/O VALVE VAULT		21	
SUBJECT 4 WET + 2 DRY WR PHITAP		SHEET	
DESIGNED	11-7-94	CHECKED	11-8-94
	DATE		DATE

VALVE PADS:

$A = 14'-1''$
 $B = 24'-3''$ $m = 0.58$

$W = 12''$ slab
 LL (No truck) $\frac{150 \text{ psf} \times 1.4 = 210$
 $\frac{150 \text{ psf} \times 1.7 = 255}{300 \text{ psf}} \quad w_u = 465 \text{ psf}$

$M_A = 0.081 \times 0.465 \times 14.04^2 = 7.4 \text{ k/ft}$ $K_n = 116$
 $M_B = 0.010 \times 0.465 \times 24.25^2 = 2.7 \text{ k/ft}$

$V_A = \frac{0.89 \times 0.465 \times 14.04}{2} = 2.9 \text{ k/ft}$ $p_{min} = 0.0033$
 $U_{secv} = 1.87 \text{ k/ft}$ $A_s = 0.31 \text{ in}^2$
 #5 @ 12" Bot & EW
 #5 @ 8" Top Ed.

Gr. Wall:

Loads: Platform = 1.87 k/ft (max).
 wall = 0.38

$b = 1'-0''$ $f_s = 2.25 \text{ ksf}$ $\frac{2.25 \text{ k/ft}}{3.00 \text{ ksf}}$



CITY OF HOUSTON		3904-00	
PROJECT	Lift Station w/ vaults		JOB NO. 0101
SUBJECT	4 wet + 2 Dry Pumps		SHEET 22
NMP	1-19-95	CHECKED	DATE
DESIGNED	DATE	CHECKED	DATE

VALVE VAULT:

Top slab = Loads - 24" slab
 Hatch @ 30psf x 2.5 = 75
 LL: @ 300psf = 300 } x 1.4 = 525
 @ 300psf x 2.5 = 122 } x 1.7 = 717.
 6.17
 W = 797 W_o = 1242

Right Vault:

L = 27'-9" d = 21" F = 0.441
 M_u = 1.24 x 27.75² / 8 = 119.4 k/ft
 V_u = 1.24 (27.75 - 2.25) = 14.4 k/ft < φV_c = 0.85 x 2√4000 x 12 x L
 = 27.1 k/ft
 K_m = 270.7 ρ = 0.0053
 A_s = 1.33 in²/ft #8 @ 7" bottom (1.46 in²)
 #5 @ 8" top EW and TRANSV.
 to #8 → (0.47 in²/ft)

Left Vault:

L = 17'-10"
 ρ_{min} = 0.0033
 A_s = 0.83 #8 @ 12 80# (0.79 in²/ft)

WALLS: See Lift Sta 3 wet + 2 dry Pumps.

BASE SLAB:

Loads: Top slab, DL 300psf
 LL 300psf
 walls: 28.75
 20.50
 20.50
 69.75 ft x 11' x 0.150 = 115.1 k = 195 p.s.f.
 28.75 x 20.5

Consider water table to be zep to finish grade. Design Engineer to verify for 100yr flood if critical

h_w = 2'-0" zep 11ft = 15.5 x 62.4 = 967 p.s.f. ↑
 11'-0"
 2'-6"
 15'-6"



CITY OF Houston		3904-00	
PROJECT		JOB NO. 0101	
Lift Str w/Vaults		23	
SUBJECT	4 Wet + 2 Dry Pumps	SHEET	
NTMP	1-19-95	CHECKED	DATE
DESIGNED			

DL: 24" top slab = 300 psf
 12" walls = 195 "
 30" Base slab = 375 "
 870 psf ↓

Consider 1'-6" wide ftg outside.

Soil wt = $(20.5 + 20.5 + 31.75) \times 1.5 \times 14.5 \times 60 \text{ pcf} = 161 \text{ psf}$
 $28.75 \times 20.5 = 589.375$

ZDL = 1031 psf ↓ 2'-0" wide ftg → = 217 psf

FS = $\frac{1031}{967} = 1.07 < 1.2$

ZDL required = $1.2 \times 967 = 1160 \text{ psf}$

Δ net uplift = 129 psf ↑

I Increase t_{wall} = 15" = 49 psf ↑
 ftg = 2'-0" = 56 psf ↓ } = 105 psf = ΔDL

Use

II Increase wall thickness, t_w = 16" and ftg to 2'-0"

Walls: 20.50'
 20.50'
 29.42'

$70.42 \text{ ft} \times 11. \times 1.33 \times 0.150 = \frac{154.9 \text{ k}}{20.5 \times 29.42} = 257 \text{ psf}$

Soil/wt = 20.50
 20.50
 33.42'

$74.42 \times 14.5 \times 2. \times 60 \text{ pcf} = \frac{129.5 \text{ k}}{20.5 \times 29.42} = 214 \text{ psf}$

ZDL = 300 Top slab
 257 walls
 375 Base slab
 214 Backfill

1146 psf ↓ FS = $\frac{1146}{967} = 1.19 \approx 1.20$



CITY OF HOUSTON		3904-00
PROJECT		JOB NO. 01/01
Lift Station w/ Vaults		24
SUBJECT	4 wet + 2 dry Pumps	SHEET
NTMP DESIGNED	1-19-95	CHECKED
DATE		DATE

Consider Base slab as Two-way slab hinged at all edges.

LL	= 300	x 1.7 = 510
Top slab	= 300	} x 1.4 = 1080
wall 5	= 257	
soil fill	= 214	
		$w_u = 1590 \text{ psf.}$

$a = 20.50'$
 $b = 27.75'$
 $M = \frac{20.50}{27.75} = 0.74$
 $w = 1071 \text{ psf}$

$M_{uA}^+ = 1.59 \times 20.5^2 \times 0.061 = 40.8 \text{ k/ft}$ $K_m = 63$

$M_{uB}^+ = 1.59 \times 27.75^2 \times 0.019 = 23.3 \text{ k/ft}$

$d = 30'' - 2 - 2 - \frac{1}{2} = 25.5$ $f = 0.650$

$P_{min} = 0.0033$ $A_z = 1.0 \text{ in}^2/\text{ft}$
 #707" Top EW.
 #507" Bot EW.

Smaller Vault:

see 3 wet + 2 dry Pumps lift station.



HOUSTON, TX STDS.		3921-00
PROJECT		JOB NO. 0101
CONTROL BUILDING		1 OF 5
SUBJECT		SHEET
NMP	12-19-95	
DESIGNED	DATE	CHECKED
		DATE

ROOF:

Dead loads: Asphalt shingles = 3 psf
 5/8" Plywood Sheathing = 3 psf
 Roof slope 5V:12H = 22.5°
 $W_{DL} = 7 \text{ psf}$ (Horizontal projection)
 5/8" Gypsum ceiling = 3 psf
 Trusses @ 16" c/c. Approx wt. = 3 psf
 Insulation = 2 psf

Live load

$W_{DL} = 15 \text{ psf}$
 $W_{LL} = 16 \text{ psf}$
 $W_{DL+LL} = 31 \text{ psf}$

Wind load:

Design wind pressure

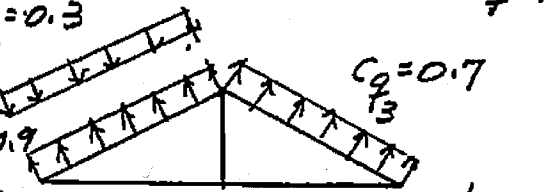
$p = C_e C_g q_s I$

where $C_e = 1.06$, Exposure C
 $C_g =$ see sketches.
 $q_s = 20.8 \text{ psf}$ for 90 MPH
 $I = 1.15$

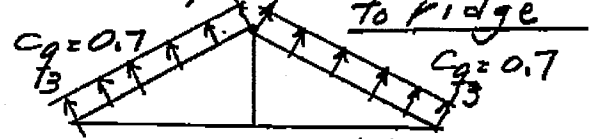
ROOF:

$C_g = 0.3$
 C_{g1}

OR
 $C_g = 0.9$
 C_{g2}



(i) Wind perpendicular to ridge



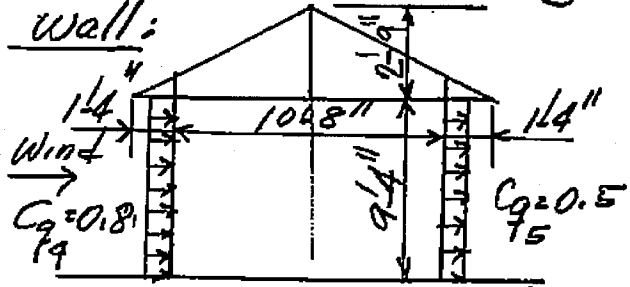
(ii) Wind-parallel to ridge

$p = 1.06 \times 20.8 \times 1.15 C_g$
 $= 25.4 C_g$

Roof:

$p_1 = 25.4 C_{g1} = 7.62$ say 8 psf
 $p_2 = 25.4 C_{g2} = 22.86$ 23 psf
 $p_3 = 25.4 C_{g3} = 17.78$ 18 psf

Wall:



(iii) Wind-any direction

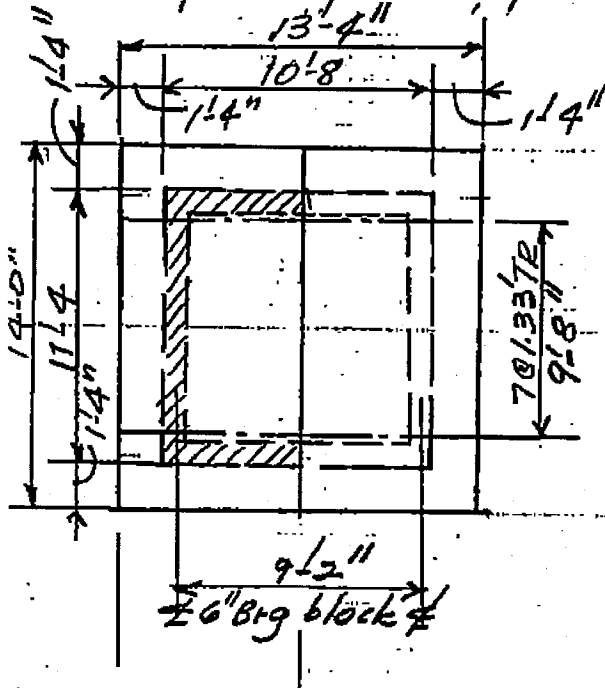
Wall:

$p_4 = 25.4 \times 0.8 = 20.32$ 21 psf
 $p_5 = 25.4 \times 0.5 = 12.70$ 13 psf



HOUSTON, TX STDS		3921-00	
PROJECT		JOB NO. 0101	
CONTROL BUILDING		2 OF 5	
SUBJECT		SHEET	
NMP	12-19-95		
DESIGNED	DATE	CHECKED	DATE

Roof trusses spaced at 16" o/c.



Wall Reaction Per truss:

$$R_{DL} = 15 \text{ psf} \times 1.33 \times \frac{13.33}{2} = 133 \#$$

$$R_{LL} = 16 \text{ psf} \times 1.33 \times \frac{13.33}{2} = 142 \#$$

$$R_{WL_1} = 8 \times 1.33 \times \frac{13.33}{2} \times \frac{7.92}{9.17} = 62 \#$$

$$R_{WL_2} = -23 \times 1.33 \times \frac{13.33}{2} \times \frac{7.92}{9.17} = -176 \#$$

$$R_{WL_3} = -18 \times 1.33 \times \frac{13.33}{2} \times \frac{1.25}{9.17} = -22 \#$$

$$R_{DL+LL} = 133 + 142 = 275 \#$$

$$R_{DL+LL+WL} = 275 + 62 - 22 = 315 \#$$

$$R_{DL-WL} = 133 - 176 - 22 = -65 \# \text{ uplift}$$

Anchor Truss to 2" x 6" wall plate w/ per Truss Hurricane ties to take 65 lbs uplift and 97 lbs lateral force.

Wall: Height of wall = h = 9'-4"
Wind load = 21 psf.

$$M_{des} = 0.75 \times 21 \times \frac{9.33^2}{8} = 171 \text{ A-lbs/ft} < M_R = 598$$

$$V_{des} = 0.75 \times 21 \times \frac{9.33}{2} = 73 \text{ lbs/ft}$$

$$V_{truss} = 1.33 \times 73 = 97 \text{ lbs}$$

N = axial load
= -275 lbs/Truss
= -65 lbs uplift/Truss.

Neglecting axial load, 6" CMU $f'_{cm} = 1500 \text{ psi}$
#5 @ 24" Vert Reinf

$$M_R = \frac{7175}{12} = 598 \text{ A-lbs/ft}$$

NOTE: Confirm #5 @ 24" Vert. Reinf. in to bond beam at top of wall.



HOUSTON, TX STDS		3921-00	
PROJECT		JOB NO 0101	
CONTROL BLDG		3 OF 5	
SUBJECT		SHEET	
NMP	12-21-95	CHECKED	DATE
DESIGNED	DATE	CHECKED	DATE

Wall Top plate: Anchored to masonry w/
5/8" Dia X 12" Long at 24" c/c.

$$M = \frac{65 \times 24}{4} = 390 \text{ in-lbs.}$$

$$V = \frac{65}{2} = 33 \text{ lbs}$$

2X6" plate (Southern Pine) Select str. $S = \frac{5.50 \times 1.5^2}{6} = 2.06 \text{ in}^3$

$$f_t = \frac{390}{2.06} = 189 \text{ psi} < F_t = 1200 \text{ psi}$$

$$v = \frac{33 \times 1.5}{8.25} = 6 \text{ psi} < F_v = 95 \text{ psi}$$

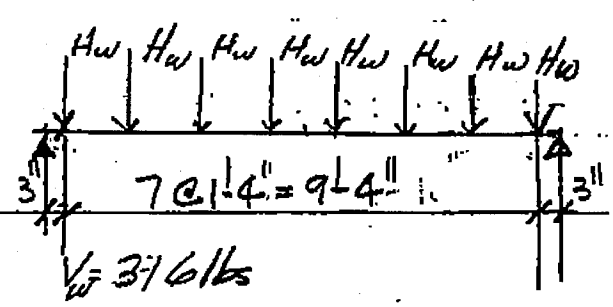
Bond beam:

8" X 8" w/ 2 #5 bars cont. w/ 2X6" wall plate
wt = 0.67 X 0.67 X 130 pcf = 58 lbs/ft

OR $1.33 \times 58 = 78 \text{ lbs/Truss}$ } 68 lbs
2 plift

Lateral load per truss per wall

$$H_w = \frac{25.4 \times 9.33 \times 1.33}{2 \times 2 \text{ walls}} = 79 \text{ lbs/Truss}$$



$$M_w = 316 \times 4.92' = 1555 \text{ ft-lbs}$$

$$- 79 \times (0.67 + 2 + 3.33 + 4.67) = -843$$

$$M_w = 712 \text{ ft-lbs.}$$

$$V_w = 316 \text{ lbs.}$$

2X6 wall $S = 7.563 \text{ in}^3$

$$f_t = \frac{712 \times 12}{7.563} = 1130 \text{ psi} < F_t = 1200$$

Bond Bm: 2#5 bars in 8" X 8" block = $0.62 \text{ in}^2/8"$

OR = $0.93 \text{ in}^2/\text{ft} \approx \#7 @ 8"$

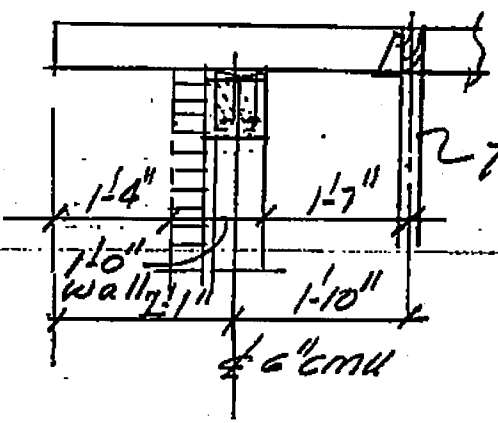
$$M_R = 20142 \text{ in-lb/ft}$$

OR $M_{Rw} = \frac{20142 \times 0.67}{12 \times 0.75} = 1500 \text{ ft-lb.}$



HOUSTON, TX STDS		3921-00	
PROJECT		JOB NO. 0101	
CONTROL BLDG		4 OF 5	
SUBJECT		SHEET	
NMP	12-21-95		
DESIGNED	DATE	CHECKED	DATE

Look-Outs:



Uplift on look-out

$$W_w = 1.33 \times 23 = 31 \text{ lbs/ft } \uparrow$$

$$W_{DL} = 1.33 \times 15 = 20 \text{ lbs/ft } \downarrow$$

$$W_{LL} = 1.33 \times 16 = 22 \text{ lbs/ft } \downarrow$$

$$M_{DL+LL} = 42 \times 2.08^2 / 2 = 91 \text{ ft-lbs}$$

$$2 \times 4, S = 3.063 \text{ in}^3$$

$$f_t = \frac{91 \times 12}{3.063} = 356 \text{ psi } < f_t = 1200$$

$$\Delta V_2 = \frac{91}{1.83} = 50 \text{ lbs } \uparrow$$

$$V_2 = \frac{42 \times 1.83}{2} = 38 \text{ lbs } \downarrow$$

$$V_{2L} = 38 + 50 = 88 \text{ lbs}$$

$$V_{2R} = 38 - 50 = -12 \text{ lbs } \uparrow \text{ uplift at Truss}$$

$$W_{DL+WL} = -31 + 20 = -11 \text{ lbs/ft}$$

$$V_1 = 23 \text{ lbs } \uparrow$$

$$M_{W1} = 11 \times 2.08^2 / 2 = 24 \text{ ft-lb}$$

$$\Delta V_2 = \frac{24}{1.83} = 13 \text{ lbs}$$

$$V_2 = \frac{11 \times 1.83}{2} = 10 \text{ lbs}$$

$$V_{2L} = -10 - 13 = -23 \text{ lbs } \uparrow$$

$$V_{2R} = -10 + 13 = 3 \text{ lbs}$$

max. uplift at Wall = $V_1 + V_{2L} = -46 \text{ lbs } \uparrow$

Provide Hurricane Strap between 2x4 Look-Outs and 2x6 Wall plate. Anchor wall plate w/ 5/8" ϕ @ 24" into CMU Bond beam on top of wall.



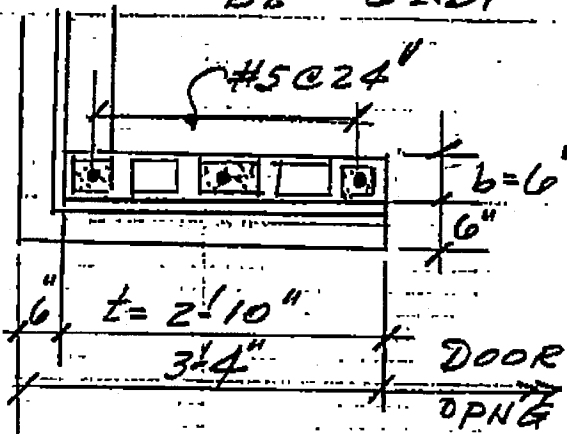
HOUSTON, TX, STDS		3921-00
PROJECT		JOB NO. 01d
CONTROL BLDG		5 OF 5
SUBJECT		SHEET
NMP	12-21-95	
DESIGNED	DATE	CHECKED
		DATE

End Wall:

Consider wall with door opening

$H_{top} = 316 \text{ lbs wind load on } 3\frac{1}{4}'' \text{ wall length.}$
 $M_w = 316 \times 9.33' = 2948 \text{ ft-lbs}$ $40'' - 9'' = 31''$

$V_w = 316 \text{ lbs.}$
 $b_t = 6'' \times 34''$



$d = 31''$

$A_s = 0.31 \text{ in}^2$ 1#5 Ea Face

$f_y/t = \frac{9.33}{2.83} = 3.3 > 1.5$ acts

as Flexural Element.

Allow Shear, $F_v = \sqrt{7500} = 35 \text{ psi}$

$f_u = \frac{316}{0.8 \times 5.62 \times 34} = 2 \text{ psi} < \frac{1}{2} F_v = 17 \text{ psi}$

Assume Axial load, $P = 0.$

$f_{bt} = 25 \text{ psi}$

$M_R = \frac{f_{bt} S}{12 \times 6} = \frac{25 \times 6 \times 34^2}{12 \times 6} = 2408 > 0.75 M_w = 2211 \text{ ft-lbs.}$

or $M_R = F_s A_s j d = \frac{20000 \times 0.31 \times 0.8 \times 31}{12} = 12813 \text{ ft-lbs}$

Wall load at Gr. Floor Level:

Roof: $w = 315/1.33 = 237 \text{ lbs/ft}$
 wall $(40 + 2 + 40) \times 9.33 = 765$

Gr. Floor 8" slab = 100 psf
 LL = 250 "
 $\frac{350 \text{ psf} \times 2.0'}{1} = 700 \text{ lbs/ft}$

Gr. wall 1' x 2.0' x 150 p = f = 300 lbs/ft

Allow. Soil bearing press = 2000 psf $W = 2002 \text{ lbs/ft}$
 $b = 140'' \text{ fly reqd.}$



Houston, Tx, STDS		3921-00
PROJECT		JOB NO. 0101
CONTROL BLDG		6 of 6
SUBJECT		SHEET
NMP	1-22-96	
DESIGNED	DATE	CHECKED
		DATE

Roof sheathing:

5/8" Exterior grade Plywood on trusses @ 16" c/c.
 Consider 8d (l = 2 1/2") Common nails.
 min. penetration = 2.50 - 0.63" = 1.87"
 ABC Table 25G V = 78 lbs/nail w/ 1 1/2" pen.
 25H T = 41 lb/nail/1" pen.

Allowable V = $78 \times 1.87 / 1.50 = 97 \text{ lbs}$
 Allowable T = $41 \times 1.87 = 76 \text{ lbs}$

max 2/plift = $23 \text{ psf} \times 1.33 = 31 \text{ lbs/ft along truss}$
 max shear = $\frac{14 \times 21}{2 \times 6.66} \times 2.75 \times \frac{7.21}{6.66} = 66 \text{ lb/ft along truss}$

provide 8d common nail at 8" c/c along truss. (16" c/c shear and 16" tension nails)

Tallowable = $\frac{76}{1.33} = 57 \text{ lbs/ft} > 31 \text{ lbs/ft actual}$

Vallowable = $\frac{97}{1.33} = 73 \text{ lbs/ft} > 66 \text{ lbs/ft actual}$

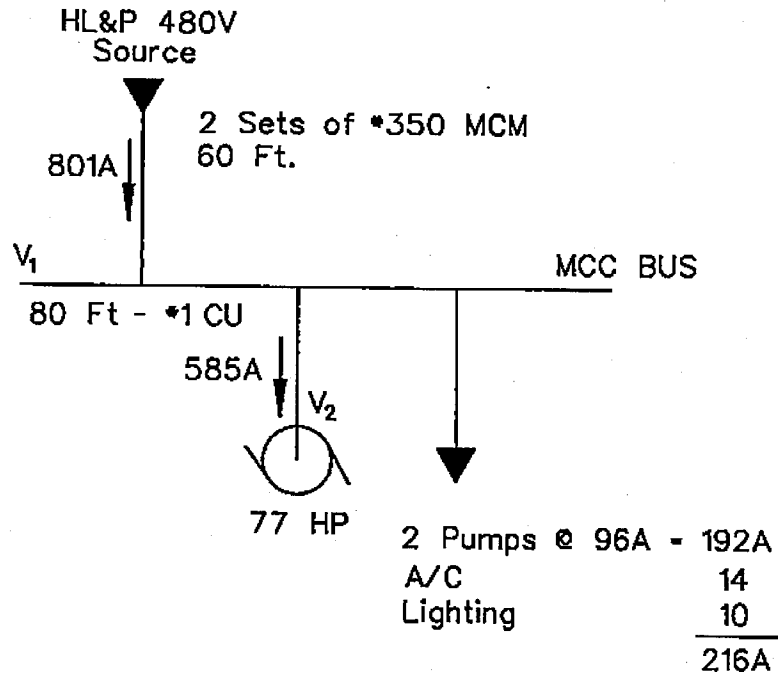
PLYWOOD NAILING SCHEDULE	
BOUNDARY NAILING	- 8d @ 4" O.C.
PANEL EDGES WITHIN 5'-0" OF ROOF EDGE @ EA. GABLE	- 8d @ 4" O.C.
OTHER PANEL EDGES & FIELD NAILING	- 8d @ 6" O.C.
ALL NAILS SHALL BE GALVANIZED COMMON NAILS	

APPENDIX C

TYPICAL ELECTRICAL DESIGN CALCULATION EXAMPLES

VOLTAGE DROP CALCULATIONS

1. Assume starting pump 3 with 2 pumps at full load and all auxiliaries on. (Pump 4 on standby).
2. Use published full load amps and starting inrush amps at 460V on 480V system.
3. Power factor = 0.95.



$$V_1 = 480 - \left(\frac{801}{2}\right)\left(\frac{60 \text{ Ft}}{1000}\right)(0.101)$$

$$V_1 = 477.6V \quad V_{D1} = \frac{(480-477.6)}{480} = 0.50\%$$

$$V_2 = V_1 - \frac{(585)(80 \text{ Ft})}{1000}(0.308)$$

$$V_2 = 477.6 - 14.4$$

$$V_2 = 463.2 \quad V_{D2} = \frac{(480-463.2)}{480} = 3.50\%$$

POWER FACTOR CORRECTION CALCULATIONS

PUMP DATA

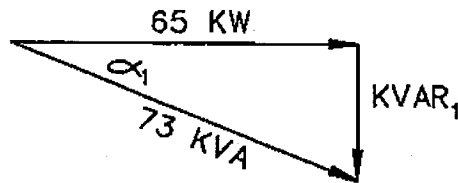
Rated Output	-	77 HP (57 KW)
Rated Input	-	92A @ 460V (65 KW)
Published PF @ 100%	-	0.89
Published PF @ 50%	-	0.82

100% LOAD

$$\text{Input KVA} = (92)(0.46)\sqrt{3} = 73 \text{ KVA}$$

$$\text{Input PF} = \frac{65 \text{ KW}}{73 \text{ KVA}} = \underline{0.89} \quad \text{- checks with published value}$$

Input Conditions:



$$\text{KVAR}_1 = \sqrt{73^2 - 65^2}$$

$$\text{KVAR}_1 = \underline{33.2}$$

Check:

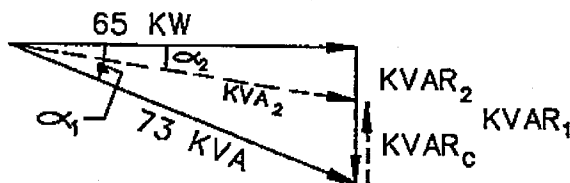
$$\alpha_1 = \cos^{-1}(0.89) = 27.1^\circ$$

$$\text{KVAR}_1 = [\sin(\alpha_1)](73 \text{ KVA})$$

$$= (0.456)(73)$$

$$= \underline{33.3}$$

To Correct PF To 0.95 LAG:



$$\text{PF} = \frac{\text{KW}}{\text{KVA}_2}$$

$$\text{KVA}_2 = \frac{\text{KW}}{\text{PF}} = \frac{65}{0.95}$$

$$= 68.4 \text{ KVA}$$

$$\text{KVAR}_2 = \sqrt{68.4^2 - 65^2}$$

$$\text{KVAR}_2 = 21.3$$

Check:

$$\alpha_2 = \cos^{-1}(0.95) = 18.2^\circ$$

$$\text{KVAR}_2 = [\sin(18.2)](68.4)$$

$$= \underline{21.3}$$

$$\begin{aligned}
 \text{KVAR}_c &= \text{KVAR}_1 - \text{KVAR}_2 \\
 &= 33.3 - 21.3 \\
 &= \underline{12 \text{ KVAR}}
 \end{aligned}$$

Standard Commercial Sizes --> 10 KVAR or 15 KVAR

Using 10 KVAR Correction:



$$\begin{aligned}
 \text{KVAR}_2 &= \text{KVAR}_1 - \text{KVAR}_c \\
 &= 33.3 - 10 \\
 &= 23.3 \text{ KVAR}
 \end{aligned}$$

$$\begin{aligned}
 \text{KVA}_2 &= \sqrt{65^2 + 23.3^2} \\
 &= 69 \text{ KVA}
 \end{aligned}$$

$$\text{PF} = \frac{65}{69} = 0.942$$

Using 15 KVAR Correction:



$$\begin{aligned}
 \text{KVAR}_2 &= \text{KVAR}_1 - \text{KVAR}_c \\
 &= 33.3 - 15 \\
 &= 18.3 \text{ KVAR}
 \end{aligned}$$

$$\begin{aligned}
 \text{KVA}_2 &= \sqrt{65^2 + 18.3^2} \\
 &= 67.5 \text{ KVA}
 \end{aligned}$$

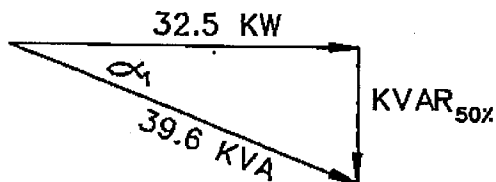
$$\text{PF} = \frac{65}{67.5} = 0.96$$

50% LOAD

100% Input KW = 65KW -->

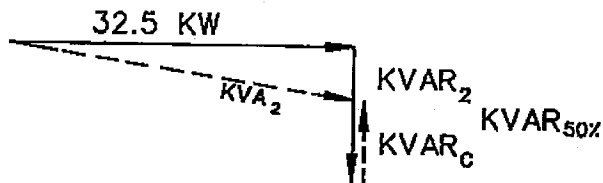
50% Input KW = 65 KW/2 = 32.5 KW

50% PF = 0.82 --> $\text{KVA}_{50\%} = \frac{32.5}{0.82} = 39.6 \text{ KVA}$



$$\begin{aligned}
 \text{KVAR}_{50\%} &= \sqrt{39.6^2 - 32.5^2} \\
 &= 22.6 \text{ KVAR}
 \end{aligned}$$

Using 10 KVAR Correction:

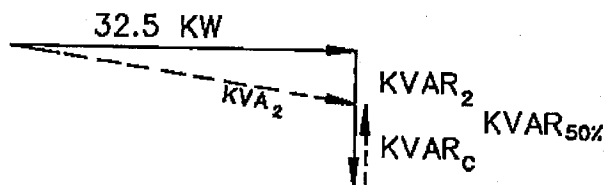


$$\begin{aligned} \text{KVAR}_2 &= \text{KVAR}_{50\%} - \text{KVAR}_c \\ &= 22.6 - 10 \\ &= 12.6 \text{ KVAR} \end{aligned}$$

$$\begin{aligned} \text{KVA}_2 &= \sqrt{32.5^2 + 12.6^2} \\ &= 34.8 \text{ KVA} \end{aligned}$$

$$\text{PF} = \frac{32.5}{34.8} = 0.933$$

Using 15 KVAR Correction:



$$\begin{aligned} \text{KVAR}_2 &= \text{KVAR}_{50\%} - \text{KVAR}_c \\ &= 22.6 - 15 \\ &= 7.6 \text{ KVAR} \end{aligned}$$

$$\begin{aligned} \text{KVA}_2 &= \sqrt{32.5^2 + 7.6^2} \\ &= 33.4 \text{ KVA} \end{aligned}$$

$$\text{PF} = \frac{32.5}{33.4} = 0.97$$

USE 15 KVAR CAPACITORS

USING 15 KVAR CAPACITORS:

$$I_c = \frac{15 \text{ KVAR}}{(0.48)\sqrt{3}} = 18\text{A}$$

Per NEC 460-8:

Minimum capacitor conductor ampacities --> of
135% of I_c or
33% of motor circuit conductors

$$I_c \times 135\% = (18)(1.35) = 24.3$$

Motor conductor ampacity (*1) = 130A

$$130\text{A} / 3 = 43.3\text{A} - \text{Minimum}$$

Use *8 CU capacitor conductors

LOAD CALCULATIONS

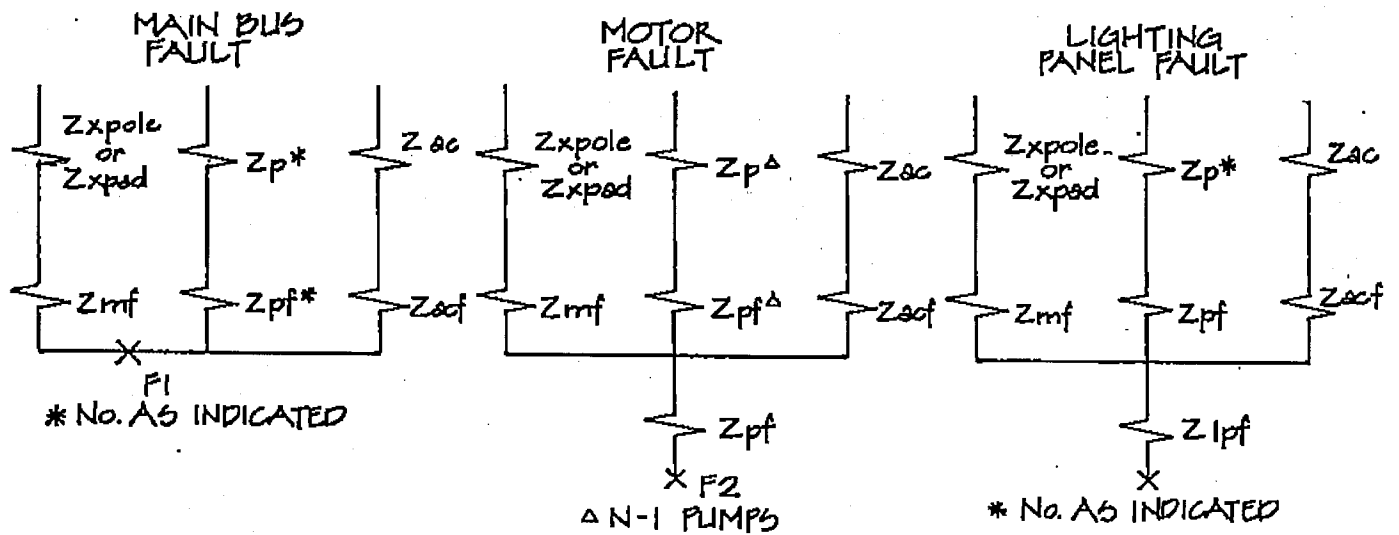
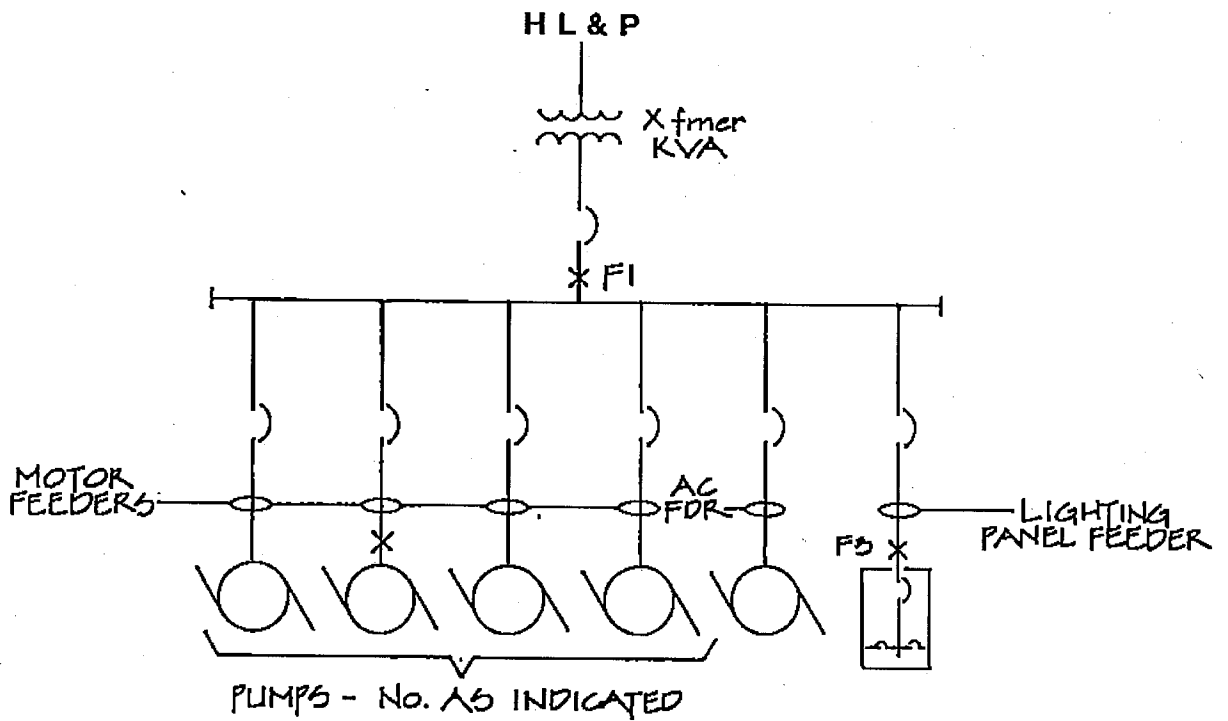
MOTOR CONTROL CENTER			
CIRCUIT	DESCRIPTION	HP / KVA	FLA
1	MAIN BREAKER	---	
2	PUMP NO. 1	75 HP	96
3	PUMP NO. 2	75 HP	96
4	PUMP NO. 3	75 HP	96
5	PUMP NO. 4	75 HP	96
6	AIR CONDITIONER	10 HP	14
7	LIGHTING TRANSFORMER	5 KVA	10
TOTAL			408

LIGHTING PANEL			
CIRCUIT	DESCRIPTION	WATTS	
1	CONTROL POWER	200	
2	MCC HEATER	150	
3	PLC		250
4	AIR COMPRESOR		500
5	LIGHTS	170	
6	SPARE	500	
7	BUILDING RECPTACLES		360
8	SPARE		500
9	SPARE	500	
10	SPARE	500	
11	SPACE		500
12	SPACE		500
TOTAL WATTS		4630 WATTS	
SERVICE VOLTAGE		240 VOLTS	
TOTAL AMPERES		19 AMPS	

FAULT CALCULATIONS

STATION TYPE	4 PUMPS @	75 HP (KVA)			
SERVICE VOLTAGE	480	BASE KV	0.48		
TRANSFORMER KVA	500	USED AS BASE KVA			
XFORMER Z – POLE MTD	0.02				
XFORMER Z – PAD MTD	0.03				
<u>FEEDERS –</u>	<u>NO.</u>	<u>AWG</u>	<u>LENGTH</u>	<u>Z tot</u>	<u>Z pu</u>
MAIN	3 –	350	100	0.002063	0.0045
PUMPS	1 –	1/0	50	0.0067	0.0145
AIR CONDITIONING	1 –	6	20	0.00988	0.0214
LIGHTING PANEL	1 –	6	20	0.00988	0.0214
<u>LOADS</u>		<u>KVA</u>	<u>Z pu</u>		
PUMPS		75	1.6667		
AIR CONDITIONING		10	12.5000		
<u>EQUIVALENT Z pu</u>		<u>POLE MTD</u>		<u>PAD MTD</u>	
XFORMER & FEEDER		0.0245		0.0345	
ALL PUMPS		2.3792			
N-1 PUMPS		1.7844			
AIR CONDITIONING		12.5214			
<u>FAULT CURRENTS</u>		<u>POLE MTD</u>		<u>PAD MTD</u>	
		<u>Z tot</u>	<u>I sc</u>	<u>Z tot</u>	<u>I sc</u>
MAIN BUS		0.0242	24870	0.0339	17744
AT MOTOR		0.0386	15564	0.0483	12458
AT LIGHTING PANEL		0.0456	13182	0.0553	10869

SHORT CIRCUIT CALCULATIONS



C-3300

SECTION PAGE

F 11

ELECTRICAL DATA

SUPERSEDES ISSUED
4/86 2/88

MOTOR DATA

Rated Output Power HP (Kw)	Ø	Vnom	Full Load Amps	Starting Amps Surge/LR	Locked Rotor KVA	NEC Code Letter	Rated Input Power (Kw)	Poles/RPM
32 (24)	3	460 575	42 34	234/164 187/131	131	D	27	8/875
6 Pole 60 (45)	3	460 575	72 58	445/287 356/230	228	C	51	6/1165
8 Pole 60 (45)	3	460 575	81 65	380/243 304/194	193	B	52	8/875
77 (57)	3	460 575	92 74	585/375 468/300	298	C	65	6/1170
88 (66)	3	460 575	108 86	590/445 472/356	354	D	73	4/1770
120 (90)	3	460 575	140 112	1030/765 824/612	609	F	100	4/1775

Pump Motor HP	EFFICIENCY			POWER FACTOR		
	100% Load	75% Load	50% Load	100% Load	75% Load	50% Load
32	87.5	86.9	84.2	0.82	0.78	0.70
60(6 Pole)	88.5	88.5	86.8	0.89	0.87	0.82
60(8 Pole)	87.5	88.0	86.5	0.82	0.79	0.71
77	87.7	87.5	86.8	0.89	0.87	0.82
88	90.0	90.0	88.0	0.85	0.82	0.75
120	90.0	90.0	88.5	0.89	0.87	0.81

CABLE DATA

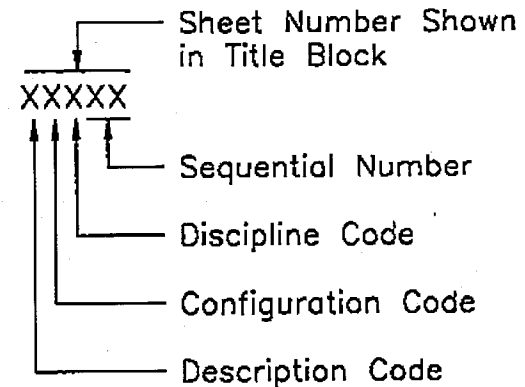
HP x Volts	Max. Length ft.	Gauge	Nominal Dia.	Conductors (in one cable)
32 x 460	630	#4/3-2-1-GC	33.8mm (1.33")	(3) #4 AWG (PWR) (2) #10 AWG (CTRL)
32 x 575	970	#4/3-2-1-GC	33.8mm (1.33")	
60 x 460	240	#4/3-2-1-GC	33.8mm (1.33")	(1) #6 AWG (GND) (1) #10 AWG (G.C.)
60 x 575	340	#4/3-2-1-GC	33.8mm (1.33")	
77 x 460	560	#1/3-2-1-GC	41.7mm (1.64")	(3) #1 AWG (PWR) (2) #10 AWG (CTRL)
77 x 575	840	#1/3-2-1-GC	41.7mm (1.64")	
88 x 460	480	#1/3-2-1-GC	41.7mm (1.64")	(1) #1 AWG (GND) (1) #8 AWG (G.C.)
88 x 575	720	#1/3-2-1-GC	41.7mm (1.64")	
120 x 460	475	#0/3-0-2-GC	42.0mm (1.65")	(3) #0 AWG (PWR) (2) #5 AWG (GND) (1) #5 AWG (G.C.)
120 x 575	745	#0/3-0-2-GC	42.0mm (1.65")	
120	Pilot Cable	#14/7	17.8mm (0.70")	(7) #14 AWG

City of Houston
 Design Guideline Drawings
 For Submersible Lift Stations
 Filename & Sheet Numbering Designation Codes

Description Codes

- A - 2-Pump Station 100 gpm per Pump
- B - 2-Pump Station 100-300 gpm per Pump
- C - 2-Pump Station 250-500 gpm per Pump
- D - 3-Pump Station 250-2000 gpm per Pump
- E - 3-Pump Station 2000-5300 gpm per Pump
- F - 4-Pump Station 500-2500 gpm per Pump
- G - 5-Pump Station 2 Dry & 3 Wet Weather Pumps
- H - 6-Pump Station 2 Dry & 4 Wet Weather Pumps
- I - Open
- J - Open
- K - Open
- L - Open
- M - Open
- N - Open
- O - Open
- P - Open
- Q - Open
- R - Open
- S - Open
- T - Open
- U - Open
- V - Open
- W - Level I Instrumentation
- X - Level II Instrumentation
- Y - Level III Instrumentation
- Z - Common Drawings

Filename Designation



Discipline Codes

- A - Architectural
- C - Civil
- E - Electrical & Instrumentation
- G - General
- S - Structural

Configuration Codes

- 0 - Dwg Non-Specific to Configuration
- 1 - Alternate High Profile Configuration
- 2 - Preferred Configuration
- 3 - Alternate Low Profile Configuration

Figure A-1

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
Z0G01	Title Page
Z0A01	Control Building, Architectural
A1C01	Plan View @ Grade & Sections, 2--Pumps @ 100 gpm per Pump, Alternate High Profile Configuration
A1C02	Elevation Sections, 2--Pumps @ 100 gpm per Pump, Alternate High Profile Configuration
A2C01	Plan View @ Grade & Sections, 2--Pumps @ 100 gpm per Pump, Preferred Configuration
A2C02	Elevation Sections, 2--Pumps @ 100 gpm per Pump, Preferred Configuration
A3C01	Plan View @ Grade & Sections, 2--Pumps @ 100 gpm per Pump, Alternate Low Profile Configuration
A3C02	Elevation Sections, 2--Pumps @ 100 gpm per Pump, Alternate Low Profile Configuration
B1C01	Plan View @ Grade & Sections, 2--Pumps @ 100 - 300 gpm per Pump, Alternate High Profile Configuration
B1C02	Elevation Section, 2--Pumps @ 100 - 300 gpm per Pump, Alternate High Profile Configuration
B2C01	Plan View @ Grade & Sections, 2--Pumps @ 100 - 300 gpm per Pump, Preferred Configuration
B2C02	Elevation Section, 2--Pumps @ 100 - 300 gpm per Pump, Preferred Configuration
B3C01	Plan View @ Grade & Sections, 2--Pumps @ 100 - 300 gpm per Pump, Alternate Low Profile Configuration
B3C02	Elevation Section, 2--Pumps @ 100 - 300 gpm per Pump, Alternate Low Profile Configuration
C1C01	Plan View @ Grade & Base Sect, 2--Pumps @ 250 - 500 gpm per Pump, Alternate High Profile Configuration
C1C02	Elevation Section, 2--Pumps @ 250 - 500 gpm per Pump, Alternate High Profile Configuration
C2C01	Plan View @ Grade & Base Sect, 2--Pumps @ 250 - 500 gpm per Pump, Preferred Configuration
C2C02	Elevation Section, 2--Pumps @ 250 - 500 gpm per Pump, Preferred Configuration
C3C01	Plan View @ Grade & Base Sect, 2--Pumps @ 250 - 500 gpm per Pump, Alternate Low Profile Configuration
C3C02	Elevation Section, 2--Pumps @ 250 - 500 gpm per Pump, Alternate Low Profile Configuration
D1C01	Plan View @ Grade & Base Sect, 3--Pumps @ 250 - 2000 gpm per Pump, Alternate High Profile Configuration
D1C02	Elevation Section, 3--Pumps @ 250 - 2000 gpm per Pump, Alternate High Profile Configuration
D2C01	Plan View @ Grade, 3--Pumps @ 250 - 2000 gpm per Pump, Preferred Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
D2C02	Elevation Section, 3-Pumps @ 250 – 2000 gpm per Pump, Preferred Configuration
D2C03	Base Section, 3-Pumps @ 250 – 2000 gpm per Pump, Preferred Configuration
D3C01	Plan View @ Grade, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate Low Profile Configuration
D3C02	Elevation Section, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate Low Profile Configuration
D3C03	Base Section, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate Low Profile Site Configuration
E1C01	Plan View @ Grade, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate High Profile Configuration
E1C02	Elevation Section, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate High Profile Configuration
E1C03	Base Section, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate High Profile Configuration
E2C01	Plan View @ Grade, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E2C02	Elevation Section, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E2C03	Sections, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E3C01	Plan View @ Grade, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3C02	Elevation Section, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3C03	Base Section, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
F1C01	Plan View @ Grade, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F1C02	Elevation Section, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F1C03	Base Section, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F2C01	Plan View @ Grade, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F2C02	Elevation Section, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F2C03	Base Section, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F3C01	Plan View @ Grade, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3C02	Elevation Section, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3C03	Base Section, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
G1C01	Plan View @ Grade, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
G1C02	Elevation Section, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
G1C03	Base Section, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
G2C01	Plan View @ Grade, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G2C02	Elevation Section, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G2C03	Base Section, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G2C04	Station Operation Tables, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G3C01	Plan View @ Grade, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3C02	Elevation Section, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3C03	Base Section, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3C04	Station Operation Tables, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H1C01	Plan View @ Grade, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H1C02	Elevation Section, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H1C03	Base Section, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H2C01	Plan View @ Grade, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H2C02	Elevation Section, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H2C03	Base Section, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H2C04	Station Operation Tables, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H3C01	Plan View @ Grade, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3C02	Elevation Section, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3C03	Base Section, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3C04	Station Operation Tables, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
Z0C01	Air Cell Assembly & Details
Z0C02	Typical Details, Civil
Z0C03	Typical Details, Civil
Z0C04	Discharge Piping Support Details
Z0C05	Catwalk Details
Z0C06	Surge Relief Valve Details
Z0C07	Typical Details, Civil
Z0C08	Typical Site Details
Z0C09	Example – Site Plan
A1S01	Structural, 2-Pumps @ 100 gpm per Pump, Alternate High Profile Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
A2S01	Structural, 2-Pumps @ 100 gpm per Pump, Preferred Configuration
A3S01	Structural, 2-Pumps @ 100 gpm per Pump, Alternate Low Profile Configuration
B1S01	Structural, 2-Pumps @ 100 - 300 gpm per Pump, Alternate High Profile Configuration
B2S01	Structural, 2-Pumps @ 100 - 300 gpm per Pump, Preferred Configuration
B3S01	Structural, 2-Pumps @ 100 - 300 gpm per Pump, Alternate Low Profile Configuration
C1S01	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Alternate High Profile Configuration
C1S02	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Alternate High Profile Configuration
C2S01	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Preferred Configuration
C2S02	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Preferred Configuration
C2S03	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Preferred Configuration
C3S01	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Alternate Low Profile Configuration
C3S02	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Alternate Low Profile Configuration
C3S03	Structural, 2-Pumps @ 250 - 500 gpm per Pump, Alternate Low Profile Configuration
D1S01	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Alternate High Profile Configuration
D1S02	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Alternate High Profile Configuration
D2S01	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Preferred Configuration
D2S02	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Preferred Configuration
D2S03	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Preferred Configuration
D2S04	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Preferred Configuration
D3S01	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Alternate Low Profile Configuration
D3S02	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Alternate Low Profile Configuration
D3S03	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Alternate Low Profile Configuration
D3S04	Structural, 3-Pumps @ 250 - 2000 gpm per Pump, Alternate Low Profile Configuration
E1S01	Structural, 3-Pumps @ 2000 - 5300 gpm per Pump, Alternate High Profile Configuration
E1S02	Structural, 3-Pumps @ 2000 - 5300 gpm per Pump, Alternate High Profile Configuration
E1S03	Structural, 3-Pumps @ 2000 - 5300 gpm per Pump, Alternate High Profile Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
E2S01	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E2S02	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E2S03	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E2S04	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E3S01	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3S02	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3S03	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3S04	Structural, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
F1S01	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F1S02	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F1S03	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F2S01	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F2S02	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F2S03	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F2S04	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F3S01	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3S02	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3S03	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3S04	Structural, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
G1S01	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
G1S02	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
G1S03	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
G2S01	Structural, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G2S02	Structural, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G2S03	Structural, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G2S04	Structural, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G3S01	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3S02	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
G3S03	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3S04	Structural, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H1S01	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H1S02	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H1S03	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H2S01	Structural, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H2S02	Structural, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H2S03	Structural, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H2S04	Structural, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H3S01	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3S02	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3S03	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3S04	Structural, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
Z0S01	Structural – Typical Details
Z0S02	Structural – General Notes
A1E01	Conduit Layout, 2-Pumps @ 100 gpm per Pump, Alternate High Profile Configuration
A2E01	Conduit Layout, 2-Pumps @ 100 gpm per Pump, Preferred Configuration
A3E01	Conduit Layout, 2-Pumps @ 100 gpm per Pump, Alternate Low Profile Configuration
B1E01	Conduit Layout, 2-Pumps @ 100 – 300 gpm per Pump, Alternate High Profile Configuration
B2E01	Conduit Layout, 2-Pumps @ 100 – 300 gpm per Pump, Preferred Configuration
B3E01	Conduit Layout, 2-Pumps @ 100 – 300 gpm per Pump, Alternate Low Profile Configuration
C1E01	Conduit Layout, 2-Pumps @ 250 – 500 gpm per Pump, Alternate High Profile Configuration
C2E01	Conduit Layout, 2-Pumps @ 250 – 500 gpm per Pump, Preferred Configuration
C3E01	Conduit Layout w/JB Outside Valve Vault, 2-Pumps @ 250 – 500 gpm per Pump, Alternate Low Profile Configuration
C3E02	Conduit Layout w/JB Inside Valve Vault, 2-Pumps @ 250 – 500 gpm per Pump, Alternate Low Profile Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
C3E03	Conduit Layout Sections, 2-Pumps @ 250 – 500 gpm per Pump, Alternate Low Profile Site Configuration
D1E01	Conduit Layout, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate High Profile Configuration
D2E01	Conduit Layout, 3-Pumps @ 250 – 2000 gpm per Pump, Preferred Configuration
D3E01	Conduit Layout w/JB Outside Valve Vault, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate Low Profile Configuration
D3E02	Conduit Layout w/JB Inside Valve Vault, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate Low Profile Configuration
D3E03	Conduit Layout Sections, 3-Pumps @ 250 – 2000 gpm per Pump, Alternate Low Profile Configuration
E1E01	Conduit Layout, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate High Profile Configuration
E2E01	Conduit Layout, 3-Pumps @ 2000 – 5300 gpm per Pump, Preferred Configuration
E3E01	Conduit Layout w/JB Outside Valve Vault, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3E02	Conduit Layout w/JB Inside Valve Vault, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
E3E03	Conduit Layout Sections, 3-Pumps @ 2000 – 5300 gpm per Pump, Alternate Low Profile Configuration
F1E01	Conduit Layout, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate High Profile Configuration
F2E01	Conduit Layout, 4-Pumps @ 500 – 2500 gpm per Pump, Preferred Configuration
F3E01	Conduit Layout w/JB Outside Valve Vault, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3E02	Conduit Layout w/JB Inside Valve Vault, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
F3E03	Conduit Layout Sections, 4-Pumps @ 500 – 2500 gpm per Pump, Alternate Low Profile Configuration
G1E01	Conduit Layout, 3 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
G2E01	Conduit Layout, 3 Wet & 2 Dry Weather Pumps, Preferred Configuration
G3E01	Conduit Layout w/JB Outside Valve Vault, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3E02	Conduit Layout w/JB Inside Valve Vault, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3E03	Conduit Layout Elevations, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3E04	Conduit Layout Sections, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
G3E05	Conduit Layout Sections, 3 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
H1E01	Conduit Layout, 4 Wet & 2 Dry Weather Pumps, Alternate High Profile Configuration
H2E01	Conduit Layout, 4 Wet & 2 Dry Weather Pumps, Preferred Configuration
H3E01	Conduit Layout w/JB Outside Valve Vault, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3E02	Conduit Layout w/JB Inside Valve Vault, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3E03	Conduit Layout Elevations, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3E04	Conduit Layout Sections, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
H3E05	Conduit Layout Sections, 4 Wet & 2 Dry Weather Pumps, Alternate Low Profile Configuration
W0E01	Level I Instrumentation, Outdoor Control Cabinet Installation & Air Piping Schematic
W0E02	Level I Instrumentation, Outdoor Control Panel Equipment Layout & Schedule
W0E10	Level I Instrumentation, Single Phase, Control Cabinet Equipment Layout
W0E11	Level I Instrumentation, Single Phase, Control Cabinet Equipment Layout
W0E12	Level I Instrumentation, Single Phase, Single Line, & Power Wiring Diagrams
W0E13	Level I Instrumentation, Single Phase, Control Wiring Diagram
W0E14	Level I Instrumentation, Single Phase, Control Wiring Diagram
W0E15	Level I Instrumentation, Single Phase, Alternate Control Wiring Diagram
W0E20	Level I Instrumentation, Three Phase, Control Cabinet Equipment Layout
W0E21	Level I Instrumentation, Three Phase, Control Cabinet Equipment Layout
W0E22	Level I Instrumentation, Three Phase, Single Line, & Power Wiring Diagrams
W0E23	Level I Instrumentation, Three Phase, Control Wiring Diagram
W0E24	Level I Instrumentation, Three Phase, Control Wiring Diagram
W0E25	Level I Instrumentation, Three Phase, Alternate Control Wiring Diagram
W0E30	Level I Instrumentation, Control System Process & Instrumentation Diagram
X0E01	Level II Instrumentation, Outdoor Control Cabinet Installation & Air Piping Schematic
X0E02	Level II Instrumentation, Outdoor Control Cabinet Equipment Layout & Schedule
X0E03	Level II Instrumentation, Outdoor Control Cabinet Equipment Layout
X0E04	Level II Instrumentation, Outdoor Control Cabinet Equipment Layout
X0E05	Level II Instrumentation, Outdoor Control Cabinet Equipment Layout

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
X0E06	Level II Instrumentation, Outdoor Panel, Power Wiring Diagram
X0E10	Level II Instrumentation, Outdoor Power Panel, Single Line Diagram
X0E21	Level II Instrumentation, Indoor Control Cabinet Layout & Air Piping Schematic
X0E22	Level II Instrumentation, Indoor Control Cabinet Equipment Layout
X0E23	Level II Instrumentation, Indoor Control Cabinet Equipment Layout
X0E24	Not Used
X0E25	Level II Instrumentation, Indoor Panel, MCC Power Schematic & Wiring Diagram
X0E28	Level II Instrumentation, Indoor Panel, Single Line Diagram
X0E40	Level II Instrumentation, Outdoor Panel, Control System Process & Instrumentation Diagram
X0E41	Level II Instrumentation, Outdoor Panel, Control System Process & Instrumentation Diagram
X0E50	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E51	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E52	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E53	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E54	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E55	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E56	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E57	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E58	Level II Instrumentation, Outdoor Control Panel, Control Wiring Diagram
X0E60	Level II Instrumentation, Indoor Panel, Control System Process & Instrumentation Diagram
X0E61	Level II Instrumentation, Indoor Panel, Control System Process & Instrumentation Diagram
X0E70	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E71	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E72	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E73	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E74	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E75	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E76	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
X0E77	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
X0E78	Level II Instrumentation, Indoor Control Panel, Control Wiring Diagram
Y0E20	Level III Instrumentation, Air Piping Schematic
Y0E21	Level III Instrumentation, Control Cabinet Layout & Equipment Schedule
Y0E22	Level III Instrumentation, Control Cabinet Equipment Layout
Y0E23	Level III Instrumentation, Control Cabinet Equipment Layout
Y0E24	Not Used
Y0E25	Not Used
Y0E26	Level III Instrumentation, MCC Power Schematic, Control Power & Communications Wiring Diagram
Y0E30	Level III Instrumentation, Single Line Diagram
Y0E40	Level III Instrumentation, Control System Process & Instrumentation Diagram
Y0E41	Level III Instrumentation, Control System Process & Instrumentation Diagram
Y0E50	Level III Instrumentation, Control Wiring Diagram
Y0E51	Level III Instrumentation, Control Wiring Diagram
Y0E52	Level III Instrumentation, Control Wiring Diagram
Y0E53	Level III Instrumentation, Control Wiring Diagram
Y0E54	Level III Instrumentation, Control Wiring Diagram
Y0E55	Level III Instrumentation, Control Wiring Diagram
Y0E56	Level III Instrumentation, Control Wiring Diagram
Y0E57	Level III Instrumentation, Control Wiring Diagram
Y0E58	Level III Instrumentation, Control Wiring Diagram
Y0E59	Level III Instrumentation, Control Wiring Diagram
Y0E60	Level III Instrumentation, Control Wiring Diagram
Z0E01	Electrical Symbols, Legend, Lighting Fixture Symbols & Abbreviations
Z0E02	Typical Junction Box Details
Z0E03	Typical Details, Instrumentation/Electrical
Z0E04	Typical Details, Instrumentation/Electrical
Z0E05	Control Building, Instrumentation/Electrical
Z0E06	Example – Electrical Site Plan

DRAWING INDEX
COH DESIGN GUIDELINES FOR SUBMERSIBLE STATIONS

New Sht No.	Drawing Title
Z0E10	Level II or III Instrumentation, MCC Elevations
Z0E11	Level II or III Instrumentation, MCC Elevations
Z0E12	Level II or III Instrumentation, MCC Elevations
Z0E13	Level II or III Instrumentation, MCC Elevations
Z0E14	Level II or III Instrumentation, MCC Elevations
Z0E15	Level II or III Instrumentation, MCC Elevations
Z0E20	Level II or III Instrumentation, Conduit Schedules for 240V System
Z0E21	Level II or III Instrumentation, Conduit Schedules for 480V System
Z0E40	Level II or III Instrumentation, Device Ratings Schedules for 240V System
Z0E41	Level II or III Instrumentation, Device Ratings Schedules for 480V System
Z0E42	Level II or III Instrumentation, Device Ratings Schedules for 480V System
Z0E43	Level II or III Instrumentation, Device Ratings Schedules for 480V System
Z0E44	Level II or III Instrumentation, Device Ratings Schedules for 480V System

City of Houston Standard Drawings - CADD File Layering (Level) Breakdown

All Text and Text related line entities (i.e. Dimension & Leader Lines, Cross Section Lines, etc.) are placed on the layers beginning with 'T'; and each entity is placed on the layer corresponding to its color.

Example:

<u>Layer Name</u>	<u>Color</u>	<u>Linetype</u>	<u>Description</u>
TXT-1	1 (red)	Continuous	Text, Dim & Ldr lines which are red
TXT-2	2 (yellow)	Continuous	Text, Dim & Ldr lines which are yellow
TXT-3	3 (green)	Continuous	Text, Dim & Ldr lines which are green
TXT-4	4 (cyan)	Continuous	Text, Dim & Ldr lines which are cyan

All Other entities are placed on layers beginning with 'L'; and each entity is placed on the layer corresponding to its color and linetype.

Example:

<u>Layer Name</u>	<u>Color</u>	<u>Linetype</u>	<u>Description</u>
LCON-1	1 (red)	Continuous	Other entities which are Red & Continuous Lines
LCON-2	2 (yellow)	Continuous	Other entities which are Yellow & Continuous Lines
LCON-3	3 (green)	Continuous	Other entities which are Green & Continuous Lines
LCON-4	4 (cyan)	Continuous	Other entities which are Cyan & Continuous Lines
LCTR-1	1 (red)	Center	Other entities which are Red & Center Lines
LCTR-2	2 (yellow)	Center	Other entities which are Yellow & Center Lines
LCTR-3	3 (green)	Center	Other entities which are Green & Center Lines
LCTR-4	4 (cyan)	Center	Other entities which are Cyan & Center Lines
LDAS-1	1 (red)	Dashed	Other entities which are Red & Dashed Lines
LDAS-2	2 (yellow)	Dashed	Other entities which are Yellow & Dashed Lines
LDAS-3	3 (green)	Dashed	Other entities which are Green & Dashed Lines
LDAS-4	4 (cyan)	Dashed	Other entities which are Cyan & Dashed Lines
LHID-1	1 (red)	Hidden	Other entities which are Red & Hidden Lines
LHID-2	2 (yellow)	Hidden	Other entities which are Yellow & Hidden Lines
LHID-3	3 (green)	Hidden	Other entities which are Green & Hidden Lines
LHID-4	4 (cyan)	Hidden	Other entities which are Cyan & Hidden Lines

Other layers or levels may exist; i.e. LMHID-4, LSDAS-1, etc. The last digit represents the color no. & the digits between L and the last digit represent the entity linetype. Unused layers have been purged from the drawing file.

Suggested Color to Line Weights

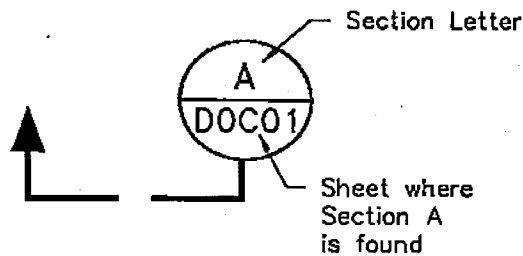
<u>Color</u>	<u>Line Weight</u>
1 (red)	0.35 mm
2 (yellow)	0.50 mm
3 (green)	0.70 mm
4 (cyan)	0.25 mm
5 (blue)	0.25 mm
6 (magenta)	0.35 mm
7 (white)	0.50 mm
8 (grey)	0.35 mm
9 (rust)	0.35 mm
10 (gold)	0.25 mm
11 (avocado)	0.25 mm

Figure A-3

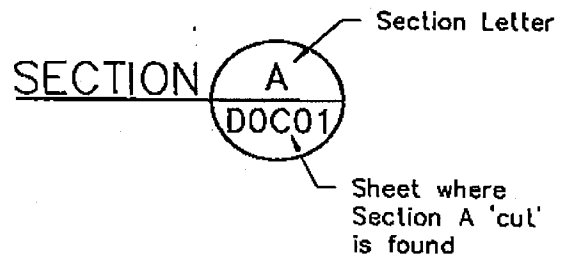
EXPLANATION OF SECTION & DETAIL INDICATORS FOR COH LIFT STATION DESIGN GUIDELINE DRAWINGS

Section Indicators

Indicator on Field of Dwg ('Cut'):

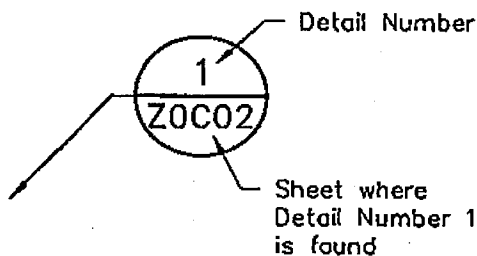


Indicator at Section:

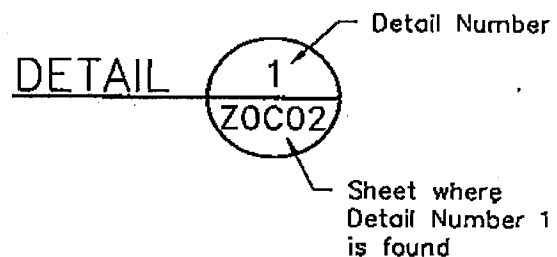


Detail Indicators

Indicator on Field of Dwg (Callout):



Indicator at Detail:



Note:

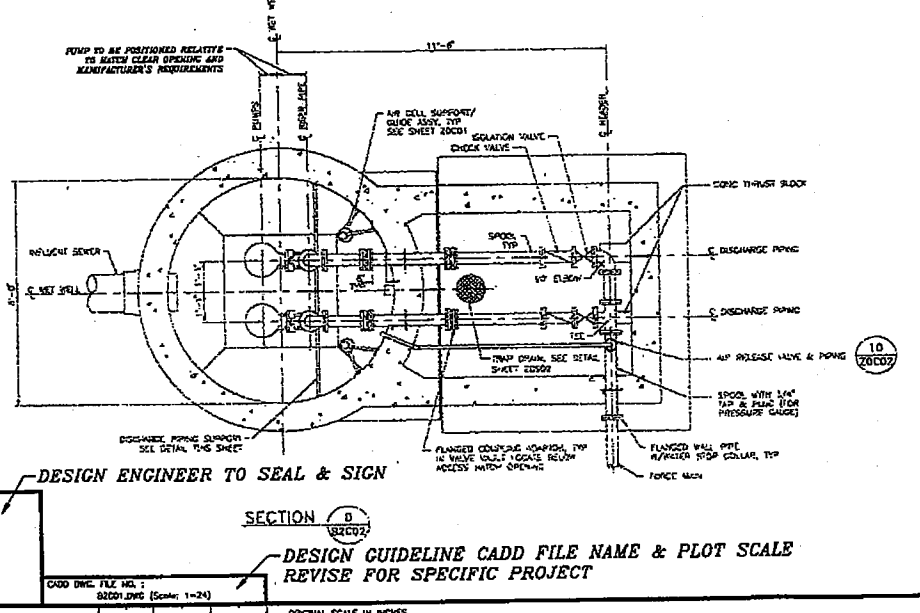
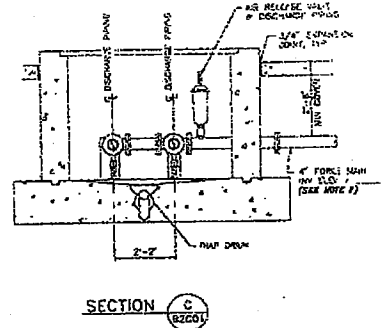
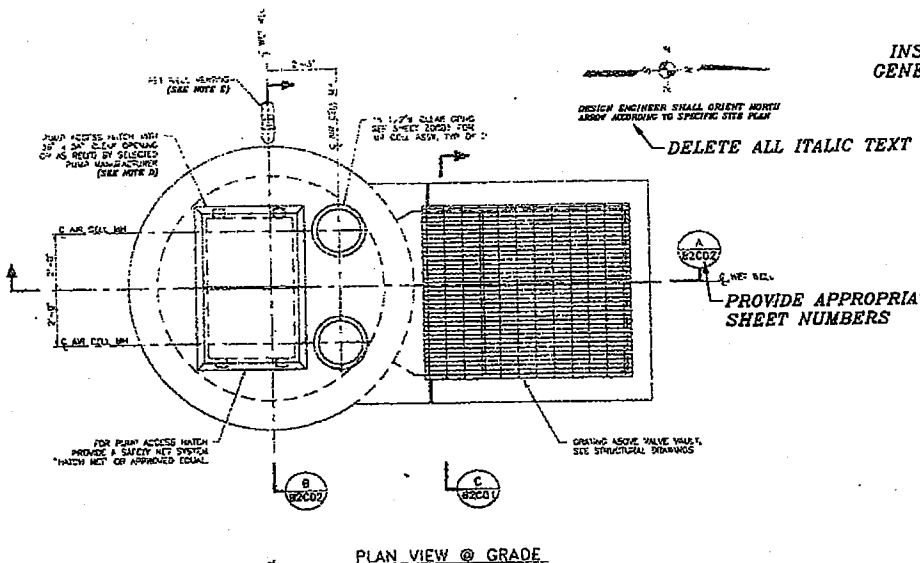
Details are not referenced back to the sheet(s) where they are called out on the Field of Dwg. These references would be numerous, and locations redundant in relation to each separate lift station configuration.

Notes:

The sheet number is located in the lower right corner of the drawing Title Block in the space labeled "DWG NO."

The sheet numbers called out on the Design Guideline Drawings are for the purposes of referencing information in the Design Guideline Drawing package. The Design Engineer shall revise all sheet number references to reflect the appropriate sheet number in his project drawing package.

**FIGURE A-5
INSTRUCTIONS FOR REVISING
GENERAL DRAWING INFORMATION
- EXAMPLE -**



- NOTES TO DESIGN ENGINEER:**
- THESE LIFT STATION DRAWINGS ARE CONSIDERED TO BE DESIGN GUIDELINES FOR THE CONSTRUCTION OF CITY OF HOUSTON WASTEWATER SUBMERSIBLE LIFT STATIONS. THESE DRAWINGS ARE TO BE USED AS FRAMEWORK FOR THE CONTRACTED DESIGN ENGINEER IN DEVELOPING SPECIFIC LIFT STATION DETAILS. IT IS THE RESPONSIBILITY OF THE CONTRACTED DESIGN ENGINEER TO VERIFY THE COMPLETENESS AND ACCURACY OF THE INFORMATION BEING OBTAINED AND TO ADJUST ACCORDING TO SPECIFIC SITE REQUIREMENTS.
 - THIS DESIGN IS BASED UPON THE LARGEST CAPACITY PUMP FOR THIS STATION (NAME: 300 - 300 GPM PER PUMP).
 - LIFT STATION DESIGN IS BASED UPON NOMINAL 4" PUMP VALVES AND PIPING AS THIS DESIGN IS ACCREDITED FOR THIS STANDARD STATION. THE DESIGN WILL REQUIRE A MINIMUM 4" PUMP VALVES AND PIPING IF SPECIFIC SITE CONDITIONS REQUIRE.
 - DESIGN ENGINEER TO VERIFY THE SIZE AND LOCATION OF THE WET WELL MANHOLES ACCORDING TO THE MANHOLE PUMP AND PUMP MANUFACTURER'S REQUIREMENTS.
 - THE ACTUAL LOCATION OF THE WET WELL VENTING MAY VARY ACCORDING TO SITE REQUIREMENTS. VERIFY PUMPING LOCATES ON THE HORIZONTAL PLAN OF THE WET WELL.
 - AVAILABILITY AND INFORMATION OBTAINED ARE DETERMINED BY DESIGN ENGINEER PER SPECIFIC SITE REQUIREMENTS.
 - SEE DETAIL AND STRUCTURAL DRAWINGS FOR DIMENSIONS AND INFORMATION NOT SHOWN.
 - THE DESIGN ENGINEER SHALL SUBMIT APPROPRIATE GUYE THE NECESSARY STANDARD OUTLINE DRAWINGS AND DETAILS INTO GUYE PAPER FOR GUYE CONSULTATION AND SHALL ADVISE PUMP MANUFACTURER AND CROSS REFERENCING ACCORDANTLY.
 - THE DESIGN ENGINEER SHALL CONSULT THE CITY OF HOUSTON DESIGN CONSULTING MANUAL, THE MANHOLE DESIGN MANUAL AND THE MASTER SPECIFICATIONS FOR PUMP CONSTRUCTION AND INFORMATION PERTAINING TO THESE STANDARD DESIGN OUTLINE DRAWINGS.
 - THE DESIGN ENGINEER SHALL INDICATE THESE NOTES, ALL REFERENCES TO THESE NOTES AND ANY OTHER EXPANDED INFORMATION FROM THE DESIGN GUIDELINE DRAWINGS. DESIGN ENGINEER SHALL PROVIDE ANY NOTES OR OTHER APPROPRIATE INFORMATION NECESSARY TO COMPLETE THE LIFT STATION DESIGN.

DESIGN ENGINEER TO READ NOTES FOR PERTINENT INFORMATION THEN DELETE

MOVE TO TOP OF SHEET

- NOTES:**
- SEE DETAIL AND STRUCTURAL DRAWINGS FOR DIMENSIONS AND INFORMATION NOT SHOWN.
 - CONTRACTOR TO CONFIRM SIZE AND LOCATION OF THE WET WELL MANHOLES PER GUYE PAPER AND PUMP MANUFACTURER'S REQUIREMENTS.
- PROVIDE ADDITIONAL NOTES AS REQUIRED**

REPLACE WITH APPROPRIATE DESCRIPTION OF INFORMATION CONTAINED ON SHEET

REPLACE WITH SPECIFIC PROJECT NUMBER

REPLACE WITH SPECIFIC PROJECT TITLE

PROVIDE SHEET NOS. ACCORDING TO PLACEMENT IN SPECIFIC PROJECT DRAWING PACKAGE

DELETE GUIDELINE DRAWING NO.

VERIFY DRAWING SCALE

ENTER CURRENT DATE

PLAN VIEW @ GRADE & SECTIONS
2 PUMPS @ 100 - 300 GPM PER PUMP
LOW PROFILE, SECURED SITE CONFIGURATION

PROJECT NO. R-0267-02-2

TITLE CITY OF HOUSTON
DESIGN GUIDELINE DRAWINGS
FOR SUBMERSIBLE LIFT STATIONS

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING
ENGINEERING, CONSTRUCTION AND REAL ESTATE GROUP

APPROVALS

WATER DESIGN WHITE AND SIGNAL DESIGN

STORM SEWER DESIGN STREET, BRIDGE & PLAW.

WASTEWATER DESIGN CONSTRUCTION

OTHER REVIEWS

PLANNING AND DEVELOPMENT

CITY ENGINEER DATE

SCALE 1/2" = 1'-0" DESIGNED BY

SUBMITTED DRAWING NO.

DATE DECEMBER, 1992 SHEET NO. OF SHEETS

DRAWN BY DATE NO. B2C01

REV. NO. DESCRIPTION APP'D DATE

READ BOOK NO.