SECTION 4
HYDRAULIC DESIGN CRITERIA

This section first presents the general design philosophy for Tacoma’s pumping stations, followed by calculations that apply to all stations. The section ends with features and design criteria needed for self-cleaning operation with fixed or variable speed pumps.

This section is not a detailed textbook covering all aspects of pumping station design. Rather, it summarizes key hydraulic features that should be incorporated in the designs of Tacoma’s pumping stations as part of the City’s standards for uniformity and operational consistency. Main topics are pump selection and wet well design. Reference is occasionally made to the following source: Pumping Station Design, Second Edition, R. L. Sanks, et.al., Butterworth-Heinemann 1998.

Figures for this section are located at the end of the section. Figures which have been reproduced from the Sanks text are used with the permission of the authors.

HYDRAULIC DESIGN PHILOSOPHY FOR SMALL (SUBMERSIBLE) STATIONS

Tacoma’s submersible pumping stations employ fixed speed, on/off level-controlled pumps operating in circular manhole wet wells with confined sumps. The term sump is used in this manual when discussing the deepest portion of the wet well room or space where the pumps or pump intakes are located. The City’s approach to the design of sumps and selection of pumps tries to address some of the shortcomings of past station designs. The Hydraulics Institute, Brown and Caldwell, and pump manufacturers have all conducted reliability field surveys and extensive laboratory testing. The cumulative research shows that reliable operation and extended equipment life can best be achieved at submersible stations when:

- Air entrainment and odor release is avoided (no influent cascade into the wet well).
- Influent discharge is horizontal and at low velocities (<4 fps).
- Solids and abrasives are immediately passed through the sump.
- Grease and rags are not allowed to build up or form rag balls.
- Pumps are carefully selected, based on their most common operational point instead of the rated or most extreme condition (i.e., with the pump operating outside the manufacturer’s preferred operating range).
- Pump cycle times are minimized to increase motor life.

When horizontal entry is provided to the sump, cost savings can be achieved by providing some of the required sump storage within the upstream piping, thus reducing the required depth of the sump.
On/off operation, rather than variable speed operation, is preferred because the industry has a poor experience with cooling jacket plugging at reduced speeds in pumps that employ pumpage fluid for cooling and has experienced increased ragging at slower speeds.

It can be a challenge to try and combine all of the favorable features listed above into one station. *Pumping Station Design, Chapter 12, especially pp 387-396* illustrates one methodology. In brief, it suggests making the last sections of influent sewer preceding the station a part of the station’s design, a part of the storage volume, with influent pipe size selected such that storage is primarily within the upstream sewer; sloping the upstream sewer sections at about 2 percent so that upon activation of a pump down cleaning cycle, scouring velocities are achieved in the influent storage pipe; using the influent pipe design to achieve entry into the well well adjacent to the pumps that is slow and gentle due to its size and slope; and locating the pump suctions in a confined manner so that they are able to pump out settleable solids and minimize rotation of flow in the sump. A sample cross section of a station designed using this approach is shown in Figure 4-5 at the end of this section.

For minor pump station remodel projects, it may not be cost-justified to modify existing wet wells and influent sewers to meet all of the recommended features described in this section. For very small stations, the designer should discuss the extent of recommended modification to the system with the City. If, for instance, there is an existing submersible station with fairly deep influent sewers, then much of the project’s cost will be in the modifications to the influent sewer. In such a case, it may be more cost effective to use well engineered drop structures and energy dissipation to try and achieve goals associated with air entrainment, odor release, and low inlet velocities into the sump, and recognize that a trade-off in pump reliability was made for reduced project capital cost.

**HYDRAULIC DESIGN PHILOSOPHY FOR LARGE STATIONS**

The same design objectives listed for submersible stations apply to larger stations as well. In addition, the station’s intake basin must provide a good environment for the pump intakes, and if the fluid contains solids and floatables, as does raw sewage, the design must allow for easy cleaning. A good intake environment includes features that minimize air entrainment, prevent vortex formation, provide for symmetrical inflow into each pump’s suction, and control current velocities that cause sequential pumps to operate differently. A good cleaning environment configures the sump so that the pump suction can remove 100 percent of settleable grit and solids and includes sump geometry that allows pump down and removal of all scum and floatables. For large stations, Tacoma has chosen as its standard configuration the self-cleaning, trench type wet well and variable speed pumping controlled so that wet well level mimics the normal depth of the influent sewer flow. With this configuration fluid and solids quickly pass through the sump, which is essentially a “fat spot in the line” and not a storage vessel or settling basin.

**HYDRAULIC CALCULATIONS**

As a minimum, completed hydraulic calculations shall include system head-capacity curves plotted against pump performance curves that have been corrected for individual pump losses, hydraulic profile versus force main profile, calculations for sump sizing, net positive suction head (NPSH) requirements, and, for fixed-speed stations, wet well storage and pump cycle time.
Station Curve or System Curve

A system curve plots head versus capacity. Capacity is usually shown on the X-axis. The system head includes static lift and all dynamic losses from the station manifold to the point of discharge. Dynamic losses shall be calculated using the Hazen and Williams C Factor method. Two separate system curves shall be generated and shown that represent the envelope of system operation. The “high” system curve shall include the highest anticipated static lift, and the greatest dynamic loss (lowest C factor). The “low” system curve shall include the lowest anticipated static lift and the least dynamic loss (highest C factor). The high C factor represents the condition of new clean pipe. The low C factor represents the condition of older, deteriorating or fouled pipe. Old tuberculated iron pipe values of 110 or lower are rarely encountered anymore. Suggested C-value ranges for new design with Tacoma pipe materials are as follows:

- Ductile iron - 120-150
- HDPE – 130-160

Calculations should always use actual inner diameters and never nominal sizes to calculate system curves.

Individual Pump Loss Curve

An individual pump loss curve represents the sum of individual pump inlet and discharge losses. Usually pump loss curves are plotted to the same scale as the system curve.

Pump Performance Curve

Full speed performance curves, representing the operation of candidate manufacturers’ products, shall be plotted against the station high and low system curves after the pump curves have been corrected for individual pump losses. Head that has been used up getting through the individual pump intake and discharge sections is not available for the force main that begins at the common manifold. Hence these losses must be subtracted from the pump curve. It is the corrected pump curves that are plotted against the system curves. Figure 4-1 at the end of this section shows the manufacturer’s published pump performance curve being corrected by inlet losses to create the corrected pump curve. Figure 4-2 at the end of this section shows an example station plot with four duty pumps. The two system curves were calculated using C factor values of 130 and 150, and the plotted pump curves are the corrected pump curves. Note that in the case of low station flow when only one pump is operating, its operation still lies within an acceptable portion of the manufacturer’s curve.

Net Positive Suction Head (NPSH) Calculations

A full discussion of NPSH is beyond the scope of these guidelines. In brief, the designer should understand that the definition of NPSH-R (required) that is published in pump vendor catalogs is derived through physical testing and by definition represents the point where head has dropped by 3 percent as the suction is throttled. Under conditions that cause a loss of head, the pump is already heavily cavitating, and therefore simply providing this level of NPSH-A (available) is a serious mistake.
The Hydraulics Institute’s standard ANSI/HI 9.6.1-1998, Centrifugal and Vertical Pumps for NPSH Margin, gives guidance regarding the margin (multiplier) that should be attained by the ratio of NPSH(A)/NPSH(R). The margin is least near the pump’s best efficiency point (BEP) which is normally near the middle of the pump curve. Margin requirements are greater near the extremes of low and high flow. Since both the test NPSH(R) values and required margins become larger the further from BEP, the product of the two becomes even greater. That is why flows at either extreme of the pump curve can be plagued by cavitation, vibration, and high radial thrust, all resulting in shortened pump life.

The Hydraulics Institute also publishes ANSI/HI 9.6.3-1997, Centrifugal/Vertical Pumps Allowable Operating Region, which defines two regions along the pump performance curve. The first is the preferred operating range (POR) near the BEP, within which the manufacturer can guarantee the design life of bearings, seals and other pump components. The second is the allowable operating range (AOR) in which the pump will still function without severe symptoms but component life will be reduced. Tacoma’s Guidespecs for pumps define multiple operating points and clearly indicate which point must fall in the POR and which can lie in the AOR. Manufacturers are just beginning to publish these values in their latest catalogs. See Pump Selection for a continuation of this topic.

The designer must select the proper NPSH margin to apply. For most installations of the size and type found in Tacoma’s collection system, minimum margin requirements will likely be 1.3 between 85 and 115 percent of BEP and 1.5 outside of that range.

The actual calculation of NPSH(A) is demonstrated in Sanks (p. 258-259).

The net result of recent research into NPSH and the cited HI standards is to emphasize the need for selection of larger, slower pumps with lower NPSH(R) characteristics and provision of deeper pump submergence to minimize potential for cavitation.

Pump Cycle Time – Fixed Speed Pumps

For fixed-speed pumps, the frequency of pump starts is determined by the wet well volume and the pumping rate. The starting frequency is important because an excessive number of starts will overheat and damage motor insulation. The larger the motor, the fewer starts per hour it can withstand. Most smaller submersible pumps are rated for 15 starts per hour, while larger, dry well pumps should usually be limited to 6 starts or less. Motor starting frequency can be decreased through alternation of pumps. The equation for determining pump cycle time is shown below. More discussion can be found in Sanks (p.370).

\[ T = \text{Pump Down Time} + \text{Fill Time} \]
\[ T = \frac{V}{Q_{\text{out}} - Q_{\text{in}}} + \frac{V}{Q_{\text{in}}} \]

Where:

- \( T \) = cycle time, minutes
- \( V \) = volume of wet well between pump control points, gallons
- \( Q_{\text{out}} \) = the average pumping rate, gallons per minute
- \( Q_{\text{in}} \) = the inflow rate (assumed constant), gallons per minute
When a pump is operating in the lead position, the minimum cycle time will occur when the inflow rate equals 1/2 the pumping rate. When this occurs, the fill time equals the pump down time and the above equation simplifies to:

\[ T_{\text{min}} = \frac{2V}{Q_{\text{in}}} = \frac{4V}{Q_{\text{out}}} \]

Solving for V provides the minimum wet well volume for a given cycle time and pumping rate:

\[ V = \frac{(T_{\text{min}} \times Q_{\text{out}})}{4} \]

The above equation for minimum cycle time is also valid for multiple pumps operating together if the pumps shut off in the same order they start up. The minimum cycle time for the last pump on will be achieved when the inflow rate is equal to the combined capacity of the other operating pumps plus one half of the incremental pumping rate of the last pump.

A control strategy that alternates the starting order of the pumps after shutoff will provide longer cycle times and rest times. However, to protect against a single or multiple pump failure, it is more conservative to size the wet well to provide adequate cycle times and rest times for all pumps, assuming that they are operating without automatic alternation. This ensures each pump can operate by itself and is particularly important on a duplex pump station.

Recall that the beginning of this section noted that storage volume can be provided entirely within the wet well (deeper station) or can be provided through a combination of wet well and influent sewer storage. The latter provides additional benefits in that it can help insure low wet well entry velocities, no odor releasing free-fall, no air entrainment, and a narrower static lift range when making pump selections.

**Pump Cycling With Variable Speed Pumps**

Minimal wet well volume is required for variable speed pumping stations and, in fact, is favorable for this operation because the objective is for fluid to pass through this “fat spot in the line” so quickly that solids cannot settle, and floatables cannot rise. The pump’s controls should be configured to match pumping rate with inflow from the upstream sewer and to regulate level to mimic the shape of the sewer’s depth-versus-capacity curve. As the level rises, indicating an increase in the rate of flow to the station, the pump in service operates at a proportionally greater speed. As the level falls, indicating a reduction in the incoming flow rate, the pump speed is reduced. Figure 4-3 at the end of this section illustrates this operating concept.

Cycling problems can occur when the inflow rate to the pump station is less than the minimum operating capacity of the lead pump if the volume in the wet well between the control points for the lead pump is not sufficient. In this situation, the variable frequency drive will perform much like a constant speed pump with a soft starter (on/off operation without the associated motor winding overheating from frequent across-the-line starting). The cycle time for the lead pump can be calculated using the general equation for pump cycle time given at the beginning of this section, assuming that the inflow rate equals one half of the minimum capacity of the variable speed drive (the worst-case situation).
HYDRAULIC PUMP SELECTION

The two most common forms of error in pump selection are similar: the selection of pumps based solely upon the highest head operating condition (rated condition), and other mistakes that ignore part of the required operating range during the life of the pump. The rated condition is often based on peak-flow storm conditions that may only occur once in twenty years, while a single pump operating at low flows and little back pressure may be the condition that exists most of the time. The single most frequent condition causing pump damage is the pump runout condition during single pump operation, a condition oftentimes totally ignored in pump specifications. Runout implies "close to running away," operating against so little back pressure and pushing so much flow that the pump is operating on the extreme right of or beyond the end of the manufacturer's published performance curve. Operation on this part of the curve is outside the manufacturer’s recommended operating region, and is a region of low efficiency, high horsepower, and an area of cavitation damage. This condition is often made worse by the fact that conservative engineers will overestimate pipe friction in their calculations. Pumps should primarily be selected for where and how they will operate most frequently. Pump specifications can identify as many conditions as are necessary to convey to the supplier the operating realm of the pump.

Since 2000, the Hydraulics Institute has required pump vendors to make available to designers information on the preferred operating range (POR) and acceptable operating range (AOR) for each pump selection. POR is centered around the best efficiency point on the manufacturer’s performance curve (typically about 70-115 percent of BEP) and is the region within which the manufacturer must guarantee low vibration operation and to meet all component life requirements. AOR extends beyond the POR (both lower flow and higher flow) and is a region in which the manufacturer anticipates smooth operation but with reduced reliability and component life (higher frequency of bearing, seal, and shaft failures typically). Below is an excerpt from one of the Tacoma pump Guidespecs. Note in particular the reference to which conditions lie in the preferred operating range of the pump and which in the allowable operating range. Those where the pump normally operates should be in the preferred operating range.

"Condition A shall be taken as the rated, continuous-duty operating condition. Performance at the rated condition shall be guaranteed in accordance with Section 11050. Condition A has been selected to obtain the rated pumping capacity for the installation. It is not intended that the pumps be selected for maximum efficiency at Condition A. Pumps furnished under this section should be selected to achieve Condition A performance, but also operate continuously without objectionable vibration or cavitation at the head specified under Condition B. Condition A may be located in the Allowable Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and published in the manufacturer’s published application data for the specific model proposed for this application.

"Condition B head is presented to indicate operating conditions when the pump is operating at maximum speed against minimum anticipated system head, assuming a hypothetical head-capacity curve. Condition B shall be used for pump selection. Condition B shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer’s published application data for the specific model proposed for this application. Pumps with head-capacity curves steeper than that assumed will produce somewhat less flow at
somewhat lower head. The reverse will occur with pumps having a shallower head-capacity curve. Proposed pump selections meeting this discharge head requirement by operating the equipment at less than full speed will be rejected. NPSHA, as listed for Condition B is calculated on a pumped flow of ______ mgd

“Condition C is the anticipated continuous duty minimum speed condition. Pumps furnished under this specification shall be capable of sustained (24 hours per day) operation at this condition within the requirements set forth in Section 11050. Condition C shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer’s published application data for the specific model proposed for this application.

“Condition D represents the expected momentary (startup/shutdown) condition. Pumps furnished under this specification will operate for no more than 30 seconds at this condition when initiating or terminating a service cycle. The maximum anticipated number of service cycles is 12 per day.”

SUMP DESIGN PARAMETERS

One of the most important aspects of sump design is to provide proper inlet conditions for the pumps. Pumps will lose efficiency and may actually be damaged from cavitation if vortices form at the entrance to the impeller, excessive air or water vapor is entrained in the sewage, or the approach velocities to the pumps are too high.

Modeling studies show that a trench type design with geometry as illustrated in Figure 4-4 at the end of this section provides the best features for wet well design of large stations. Figure 4-5 at the end of this section demonstrates key components of a submersible station.

Pump Inlet Velocity

Pump inlets should be sized to provide a maximum velocity of 3.5 fps or less at the entrance to the suction piping. The recent modeling studies show that velocities in excess of 4 fps could be acceptable. However, we recommend that peak velocities be kept below this value.

The suction piping for pumps with inlet sizes of 16 inches or less can be fitted with flared, cast iron elbows to reduce velocities. Draft tube inlets can be used for larger pumps. The inlets can be fabricated from steel in a prism shape and embedded in the concrete floor slab.

Floor Clearance

The modeling studies indicate that if pump inlets are mounted close to the floor, there is less chance of developing vortices. There is no apparent deterioration on pump performance until floor clearance is less than approximately D/8, where D is the diameter of the inlet. The best pump performance was found to be at a floor clearance of D/4. An absolute minimum clearance
of 3 inches should be maintained for wastewater pumps. The pump performance tended to
deteriorate when floor clearance exceeded the diameter of the inlet. Floor clearances required
for self-cleaning wet wells are discussed further under “Self-Cleaning Design” below. A
triangular baffle, as shown in Figure 4-6 at the end of this section, prevents instability at the
entrance to the bell. These baffles can be constructed from stainless steel plate and embedded
in the concrete slab.

Distance to End Wall

The modeling studies indicate that there is less chance of developing vortices if the inlet is
placed as close as possible to the end wall. An anti-rotation baffle prevents the development of
a current in the wastewater that can cause formation of vortices. Also, studies found that fillets
should be installed in the corners at the end of the channel.

Geometry

The modeling studies have shown improved performance if the inlet conduit is centered on the
end of the trench rather than offset. We recommend a clearance of D/4 from the end wall of the
sump and for clearance at side walls. This provides for a fairly narrow sump that works very
well for dry well pump inlets but is too narrow to accommodate submersible pump housings.
Figure 4-4 taken from Sanks suggests that suction inlet extension pieces be installed on
submersible pumps to attain the ideal inlet conditions. Tacoma could not locate successful
reference installations for this submersible configuration and vendors voiced concerns about
possible interference between the suction piece and sump when trying to lift the pump, and that
changing total suspended weight might impact pump to discharge elbow sealing. Therefore, for
Tacoma’s submersible stations, a configuration similar to Figure 4-5 shall be used.

Pump inlets should be placed 2D (where D is the diameter of the inlet) below the invert of the
influent conduit in order to prevent vortices caused by floor currents induced by the incoming
wastewater. This distance should also provide for a flooded volute when the wet well level is at
its minimum elevation at the invert of the influent conduit. The distance should be increased if
necessary to assure that the volute will be installed below the minimum wet well level.

Orientation and Velocity Past Pump Inlets

Recommendations established by the Hydraulics Institute suggest that velocities in the sump
area above the pumps should not exceed 1 fps. See Sanks, p. 360.

Separation between Pump Inlets

The modeling studies have shown that pump intakes could be almost touching with no
deterioration of pump capacity. A centerline separation of 1.25 D can be used for design
purposes. In dry well type designs, the pump intake piping can be angled to reduce the
distance between pump intakes and keep sump size to a minimum.
**SELF-CLEANING DESIGN**

Designing a wet well to be self-cleaning is important to prevent buildup of solids during normal pump operation and to allow easy removal of sediment and floatables from the wet well during the manual cleaning cycle. The basic elements of a self-cleaning wet well and the use of circular and rectangular shaped wet wells are discussed in this section. Self-cleaning wet wells for constant speed pumps require that the wet well size be minimized by utilizing storage in the upstream sewer. This will be described further in a subsequent section.

**Elements of a Self-Cleaning Wet Well**

Self-cleaning wet wells depend upon the following basic elements:

1. The wet well is shaped so that the only flat surfaces occur directly under the pump inlets. Inclined surfaces should be angled greater than 60 degrees to ensure that solids migrate to the pumps.

2. The pump inlets are located in a pocket or well which, during the cleaning cycle, minimizes the free water surface when the water draws down. Minimizing the free water surface allows the pumps to effectively remove floatables when the water surface is drawn down to the point where the pump breaks suction.

3. In rectangular wet wells, the trench is designed to sluice solids to the end of the trench for removal by the last pump in the array.

**Self-Cleaning Circular Wet Wells**

The principles set forth above can be incorporated into a wet well which is circular by sloping the sidewalls into a small trench where the pumps are located.

**Self-Cleaning Rectangular Wet Wells**

Rectangular wet wells are generally most suitable when more than two or three pumps are required or when the pumps are relatively large. Self-cleaning, rectangular wet wells include a ramp from the sewer outlet to the floor of the trench. The ramp is useful in directing incoming flow during the cleanout process into the trench and along the floor to the last pump. The modeling studies have shown that a hydraulic jump develops on the ramp as the wet well is lowered during the cleanout cycle. The jump fluidizes deposits on the floor of the wet well and moves the material to the pump inlets. A motorized gate at the inlet to the wet well can be used to vary the rate of inflow with respect to pumping rate. The gate is adjusted to carefully move the jump along the floor of the wet well and sluice material toward the last pump. The cleaning sequence is illustrated with photos in Sanks (pp. 366-367). A ramp shaped like the spillway on a dam (Ogee curve) helps to redirect the energy gained by the water moving down the ramp to a horizontal jet parallel to the floor of the trench. See Figure 4-4 at the end of this section.

For cleaning purposes, the optimum floor clearance for the pump inlets is D/4 as described above. The upstream inlets should be installed with a slightly greater clearance of D/3 to avoid
interference with the hydraulic jump during cleaning operations. The last inlet is the one used for cleaning and should be located at a clearance of D/4 above the trench floor. If D is less than 12 inches, locate the last pump’s inlet D/2 over a pocket in the floor of the trench D/4 deep.

**EFFECT OF PUMP CONTROL**

The self-cleaning wet well features can be applied to either constant speed or variable speed pumping stations as described below.

**Constant Speed Pumps**

Applying the self-cleaning wet well concepts to a constant speed pumping station is difficult, since a wet well of minimum dimensions is required. However, sufficient wet well volume must be supplied in order to prevent overheating of the pump motor due to the pump starting too frequently. In order to provide these features at a reasonable cost, a portion of the incoming sewer must provide part of the wet well volume as shown in Figure 4-7 at the end of this section.

The incoming sewer can be sloped from an upstream manhole at a 2 percent grade to produce acceptable scouring velocities, and the pipe diameter can be increased. The pipe diameter should be selected to limit critical depth to 0.6 of the pipe diameter or less. This limitation results in maximum recommended flow rates in approach sewers as shown below:

<table>
<thead>
<tr>
<th>Pipe diameter, inches</th>
<th>Flow rate, gpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>347</td>
</tr>
<tr>
<td>12</td>
<td>486</td>
</tr>
<tr>
<td>15</td>
<td>833</td>
</tr>
<tr>
<td>18</td>
<td>1,320</td>
</tr>
<tr>
<td>21</td>
<td>1,870</td>
</tr>
<tr>
<td>24</td>
<td>2,570</td>
</tr>
<tr>
<td>27</td>
<td>3,400</td>
</tr>
<tr>
<td>30</td>
<td>4,370</td>
</tr>
<tr>
<td>33</td>
<td>5,410</td>
</tr>
<tr>
<td>36</td>
<td>6,730</td>
</tr>
</tbody>
</table>

These values are based on a Manning’s n of 0.010 and a slope of 2 percent. For a Manning’s n of 0.012, the maximum recommended flow rate increases by 15 percent. Observing this limitation will avoid air entrapment when the flow goes through a hydraulic jump. The sewer should be flattened a few diameters upstream from the pumping station wet well and enter the wet well at an invert elevation equal to the “pump off” elevation for the normal start/stop cycle.
Variable Speed Pumps

The self-cleaning wet well concepts are most easily applied to stations with variable speed pumps since minimal wet well volume is required. The pump controls should be configured to match pumping rate with inflow from the upstream sewer and to regulate level to mimic the shape of the sewer’s depth versus capacity curve as shown in Figure 4-3. This provides for adequate velocities in the influent sewer and minimum wet well volume.

APPURTENANCES

Wet well appurtenances should be selected to provide efficient and safe operation and long service life. A brief discussion of common wet well appurtenances follows.

Wall Penetrations

Penetrations of the walls between the wet well and the adjacent ground and between the wet well and dry well should be made with an embedded pipe spool with attached weep ring. Penetrations with enlarged spools with expanding rubber seals may not provide adequate isolation of the wet well because they depend on correct installation, no movement of pipes with respect to the wall, and no deterioration of the materials. Expanding rubber seals should be used with caution and should not be used for penetrations between classified and unclassified areas for the reasons listed above.

Vortex Breakers

Vortex breakers (anti-rotational baffles) may be required for some pumping installations as shown in Figure 4-4. These baffles can be fabricated from steel and installed on either the sump walls or isolation sluice gates ahead of pump intake draft tubes.

CLEANING

The pumping station wet well will be designed for self-cleaning by manual operation of the pumps to draw down the wet well to remove grease buildup and solids deposits. This drawdown should be performed on a monthly basis or as determined by experience at the specific pumping station. The vortex swirl caused by this method will pull grease and other material into the pump suction. Service water utility stations and hose racks should be provided for washdown of the station. The service water should have a minimum pressure of 90 psi and flow rate of 50 gpm. The City has decided to standardize upon a higher pressure of 120 psi.
Figure 4-1. Correcting Pump Curve to Account for Individual Pump Losses
Figure 4-2. Typical Head-Capacity Curve
**Figure 12-35.** Design concepts for variable-speed pumping with the sewer used as part of the pump sump. After Brown and Caldwell Consultants.

**Figure 4-3.** Variable Speed Control Concept (Sanks Figure 12-35)
Figure 4-4. Self-Cleaning Trench Wet Wells (Sanks Figure 12-32)
Figure 4-5. Self-Cleaning Submersible Sumps (Hosmer Pumping Station)

GENERAL NOTES:
1. INSTALL PLASTIC INTERIOR LINING PER SECTION 06860 TO ALL CONCRETE SURFACES OF PIT WELL ABOVE EL. 295, INCLUDING THE UNDEREDGE OF SLAB. SEE NB, FOR INSTALLATION OF PLASTIC LINING SYSTEM TERMINATIONS, AND LIPS. INSTALL TERMINATION BELLOWS TYPE 52, SHOWN ON NB, FOR TERMINATION AT ELEVATION 295.
2. FLOOR OF FLOW METER VAULT AND VALVE VAULT SHALL BE NOT LESS THAN 6 FEET BELOW TOP OF VAULT COVER.
3. PROVIDE REPLACEMENT SPOOL PIECE FOR FLOW METER, MOUTH FLANGE, FACE TO FACE DIMENSION OF FLOW METER.
4. COAT ALL ENDED PIPES, FITTINGS AND FITTINGS PER SECTION 09260.
5. ALL NUTS, BOLTS AND WASHERS SHALL BE TYPE 316 STAINLESS STEEL.
6. INSTALL WATERPROOFING TO EXTERIOR SURFACES OF PUMP WELL PER SECTION 06180.
7. TERMINATIONS AND PENETRATIONS OF PLASTIC LINING SHALL CONFORM TO SECTION 06860 AND DETAILS E, B AND D.
8. PRECAST CONCRETE SHALL BE CLASS B CONCRETE PER SECTION 03690.

KEY NOTES:
1. TYPE 316 STAINLESS STEEL FLOW METER, INSTALL PER PUMP MANUFACTURERS RECOMMENDATIONS.
2. INSTALL PUMP SUPPORT FRAME PER MANUFACTURERS RECOMMENDATIONS.
3. CORE DRILL EXISTING MANHOLE FOR INSTALLATION OF NEW 24" RS. INSTALL PIPE USING HOSE SEAL FLEXIBLE PIPE TO MANUFACTURER CONNECTION OR APPROVED EQUAL.
4. STAINLESS STEEL, TYPE 316, GUIDE RAIL.
5. PROVIDE STRAIN RELIEF CABLE GRIP; SUPPORT CABLE FROM HOOK WITH 3/8" NYLON LINE.
6. SEE ELECTRICAL DETAILS FOR CABLE AND CONDUIT ROUTING OUTSIDE MANHOLE.
7. INTERMEDIATE GUIDE BAR BRACKETS LOCATED PER PUMP MANUFACTURERS RECOMMENDATIONS.
8. INTERMEDIATE STEEL SUPPORTS LOCATED PER VALVE GATE MANUFACTURERS RECOMMENDATIONS.
9. 3/16" STAINLESS, TYPE 4 STRUCTURAL ATTACHMENT PER DET BIM.
10. LATERAL PIPE RESTRAINTS INSTALLED PER DET CMR.

Page 4-16

Rev Date: 4/6/04
Figure 4-6. Floor Vanes for Trench Wet Wells
Figure 4-7. Wet Well Storage: Traditional versus Self-Cleaning