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WATER PLANT DESIGN STANDARDS

8-10.0.0 WATER PLANT DESIGN STANDARDS

8-10.1.0 General

1.1 Purpose

This section describes the design standards and requirements for public water plant projects.

1.2 Definitions

Section 8-18 contains a list of definitions, abbreviations, and acronyms.

1.3 Applicability

The design standards and requirements listed herein apply to all plant projects including potable (drinking water) projects, nonpotable (reclaimed water) projects, system modification (other public agency) projects, and developer-financed projects.

8-10.2.0 Water Pumping Station Requirements

The requirements described below are based, in part, on ADEQ Engineering Bulletin No. 10, Chapter 3, Pumping Facilities.

This subsection contains the following major topics:

- Site Requirements
- Pumping Units
- Headers and Yard Piping
- Hydropneumatic Tanks

2.1 Site Requirements

This subsection contains the following topics:

- Title of Property
- Site Conditions
- Site Access
- Site Surface
- Sanitary Control Distances
- Site Clearances
- Site Size and Shape
- Site Enclosures
- Site Drainage
- Site Elevation

A. Title of Property

The property for a pumping station will normally be conveyed in fee title to Tucson Water or the City of Tucson.

B. Site Conditions

The site shall meet at least one of the following conditions for access:

1. Have sixty feet or more of frontage directly along at least one public street having a right of way width of at least sixty feet, or

2. Have an access easement of at least thirty feet in width from a public right of way to the site, or

3. Access that has drainage problems, is unduly steep, or has conditions that limit access will not be acceptable unless remediated and approved by Tucson Water.

C. Site Access

1. Access shall be an all-weather road of not less than twelve feet in width, except that access roads, which exceed fifty feet in length, shall not be less than sixteen feet in width.

2. An all-weather road is defined as an improved surfacing with drainage improvements as required. Improved surfacing will be gravel, chip-seal, asphaltic concrete, or concrete as determined by Tucson Water on a project-specific basis.

D. Site Surface

Gravel surfacing of the interior of the site shall be required to provide reasonable access to all components of the pumping station.

E. Sanitary Control Distances

Sanitary control distances shall be as required by ADEQ.

F. Site Clearances

Sites being conveyed to Tucson Water or the City of Tucson shall comply with all requirements of the City of Tucson Real Estate Division, which includes, but may not be limited to, the following:

- Archaeological Clearance
- Environmental Site Assessment Clearance
- Biological Assessment Clearance

G. Site Size and Shape

The pumping station site shall be of a sufficient size and appropriate shape to allow for all equipment and any necessary maintenance and repair activities, but in no case shall it be less than 8,000 square feet. The narrowest side shall be not less than one-half the dimension of the widest side.

H. Site Enclosures

All sites shall be enclosed by an intruder resistant enclosure. The security enclosure shall be completely located within the property boundary of the site, and shall include one sixteen-foot (minimum) drive-through gate and one three-foot walk-through gate. Gates shall be of equivalent height as enclosure and shall be lockable. Depending on the site location, an acceptable enclosure may be one of the following:

1. Chain link fencing with a minimum height of six feet of chain link fabric, with three strands of barbed wire on top, for total fence height of seven feet, minimum, or

2. Masonry wall with a minimum height of seven feet.

I. Site Drainage

All sites shall be designed to allow for drainage of storm water and for any drainage of the pumping station for testing, maintenance, or repair.

1. Use drainage swales, curbs, culverts, storm sewers, or a combination thereof, as required, to provide internal site drainage.

2. If an offsite storm sewer or major drainage way is available, site drainage shall be collected before leaving the site.

3. The internal site collection system shall be sized to accommodate storm water as well as any additional water from testing of the pumping station or drainage for repairs.

J. Site Elevation

The site shall be located at an elevation that allows for provision of required Net Positive Suction Head to the pumps.

2.2 Pumping Units

This subsection contains the following topics:

- General Requirements
- Type of Pumps
- Operations
- Electric Motor Drivers
- Design Requirements

A. General Requirements

1. Pumps shall be designed to maximize efficiency and flexibility of operation. Options may include:

    a. Use of controls to alternate starts between pumping units,
    b. Pumping units sized to meet flows and pressures required, and
    c. Use of variable speed controllers.

2. All pumps in a pumping station shall have the same discharge pressure, with due consideration for frictional head losses.

B. Type of Pumps

The following types of pumps are acceptable:

1. End-suction centrifugal
2. Horizontal split-case centrifugal
3. Vertical turbine
4. Multi-staged

C. Operations

1. Pump speeds shall be between 1,800 rpm to 3,600 rpm (nominal).

2. Minimum discharge pressure shall be in accordance with Tucson Water's standard pressure zone requirements.

3. Pump operation shall be controlled by either pressure differentials as a function of demand or tank level of water storage facility.

4. Pressure sensing and pump control shall be in accordance with these standards.

5. Pumping units shall be controlled such that the unit is shut down and locked out of operations in either a low suction pressure condition, or a high discharge pressure condition.

D. Electric Motor Drivers
1. Electric motors of 350 horsepower and less shall be three-phase, 480 volt.
2. Electric motors shall be sized to accommodate the maximum design-operating load of the station pump without using the motor service factor.
3. The minimum service factor shall be 1.15.
4. Motor enclosures may be open drip proof, WP-1, or totally enclosed, fan cooled.
5. Motors of fifty horsepower or more shall have reduced-voltage starting.

E. Design Requirements
1. For pressure-controlled sites, the pump shall be designed with an operating band of twenty pounds per square inch (nominal). The "on" position will be ten pounds per square inch below the designed operating pressure, and the "off" position will be ten pounds per square inch above the designed operating pressure.

2. The actual pumping head at the "off" position shall not be less than ten feet below the total pump head on the specific pump curve at the far left (0 gallons per minute flow) point of the curve.

3. The vibration limit of a pump shall be as described in the Hydraulic Institute Standards, except that peak-to-peak vibration amplitude shall not exceed two mils for any frequency at any distance from base to point of measurement.

2.3 Headers and Yard Piping

This subsection contains the following topics:

- Definitions
- Materials
- Piping System Design Requirements
- Layout and Clearances
- Valves and Appurtenances on Header and Lateral Piping
- Valves and Appurtenances on Yard Piping

A. Definitions

For the purpose of this Design Standard, the following terms shall have the following definitions which are unique to Section 8-10:

1. "Suction Header" refers to the piping on the suction side of the station that distributes water to the suction laterals of the pumps.

2. "Suction Lateral" refers to piping from the suction header to the suction side of each pump. For vertical turbine pumps, this will also include the pump can.

3. "Discharge Header" refers to the piping on the discharge side of the pumping station that collects water from the discharge laterals of the pumping units.

4. "Discharge Lateral" refers to the piping from the discharge side of each pump to the discharge header.

5. "Yard Piping" refers to the below ground and suction and discharge piping on the pumping station site that connects the pumping station headers to the distribution system.

B. Materials

Above-ground piping shall be fabricated or mill type standard steel pipe in accordance with ASTM A53. Below-ground piping may be steel pipe, ductile iron pipe, or PVC, except that below-ground headers and laterals shall be steel pipe.

1. Ductile iron pipe and materials shall conform to the requirements of Section 1401 of the Tucson Water Standard Specifications with the following fittings:

   a. Flanges shall be Class 125 in accordance to ANSI B16.1 for operating pressures up to 250 pounds per square inch. For operating pressures above 250 pounds per square inch, flanges shall be Class 250 in accordance with ANSI B16.1.
   b. Nuts and bolts shall be grade 316 stainless steel.
   c. Gaskets shall be Grade 1 (rubber) or Buna N.

2. PVC pipe and fittings shall conform to the requirements of Section 1404 of the Tucson Water Standard Specifications.

3. Steel pipe and materials shall be fabricated or mill-type standard steel pipe in accordance with ASTM A53.

   a. The minimum wall thickness shall be as follows:

      - Less than 5-inch diameter: Schedule 40
      - 6 to 10-inch diameter: 3/16–inch
      - 12 to 14-inch diameter: 7/32–inch
      - 16 to 42-inch diameter: 1/4-inch
      - 48 to 60-inch diameter: 3/8 –inch
      - 66 to 72-inch diameter: 1/2-inch

   b. Fittings

      - Flanges shall be Class 125, ANSI B16.1, for operating pressures up to 250 pounds per square inch. For operating pressures above 250 pounds per square inch, flanges shall be Class 250, ANSI B16.1.

      - Above-ground fittings shall be flanged, welded, or coupled. Nuts and bolts shall be hot dip galvanized steel or epoxy painted.

      - Below ground fittings shall be welded or coupled. Nuts and bolts shall be grade 316 stainless steel.

      - Gaskets shall be Butyl or EPDM.

4. Protective Coating

   a. Internal coating shall be a three-coat, two-component catalyzed epoxy system. The epoxy system shall conform to all NSF requirements for potable water service. The minimum thickness shall be 12.0 dry mils, but in no case shall any individual coat be less than 4.0, nor more than 7.0 dry mil.

   b. External coating for above-ground service shall be a two-coat, two-component epoxy system or a polyurethane system. The thickness of this coating system shall be between 6.0 and 9.0 dry mils. The first coat shall be between 4.0 and 6.0 dry mils, and the second coat shall be between 2.0 and 3.0 dry mils.

   c. External coating for below-ground service shall be a factory-applied polyurethane system, as approved by Tucson Water.

C. Piping System Design Requirements

1. The flow velocity in suction headers before any reducers shall not exceed three feet per second.

2. The flow velocity in discharge headers shall not exceed five feet per second.

3. Design thrust restraint is required for all above-ground and below-ground pipe installation.

4. Use restrained joints, welded joints, or joint harnesses for thrust restraint. Reaction blocking and anchors will only be allowed for special conditions as approved by Tucson Water.

5. The design for use of flexible couplings shall allow for expansion, contraction, and maximized serviceability of equipment and will provide for a restrained joint.

6. Corrosion control of below-ground metallic pipe shall be in conformance with Section 8-11 of these Design Standards.

D. Layout and Clearances

1. As a minimum, allow the larger of three feet or two pipe diameters of clear space from the outside of header piping to any wall, fence, or structure to provide adequate access to valves and fittings.

2. Provide adequate space for access between headers, laterals, pumps, motors, and other appurtenances to allow for maintenance and repair. Specific requirements will vary depending on physical layout and size of components.

3. Suction laterals from the suction header to the pump suction nozzle shall be as short and direct as possible. Reducers used in the suction lateral shall be eccentric reducers, with the flat side on top to reduce the potential for entrapped air in the suction lateral. The lateral angle from one end of the reducer to the other shall not be greater than fifteen degrees.

4. Yard piping shall be located in areas easily accessible for maintenance and repair.

5. Clearance between waterlines and sanitary sewers shall conform to the requirements set forth by ADEQ.

E. Valves and Appurtenances on Header and Lateral Piping

1. Provide an isolation valve on the suction and discharge lateral of each pump for isolation from the headers.

2. Provide a silent check valve on the discharge lateral of each pump, between the pump and the isolation valve to prevent reverse flow when the pump is off.

3. Provide a combination air-vacuum release valve on the high point of the suction header to release air trapped in lateral piping.

4. Provide a magnetic flow meter on the discharge header.

   a. The flow velocity in the flow meter shall be in the range of one to fifteen feet per second for all designed flow conditions.

   b. A minimum of five pipe diameters of clear, unobstructed piping shall be provided on each side of the flow meter.

   c. If the discharge header piping requires reduction in size to obtain the desired flow velocity, said reduction shall be by means of eccentric reducers placed outside of the five pipe diameter clear distance from each side of the meter.

5. A test head lateral and isolation valve shall be provided off the discharge header for performance testing.

6. Provide sufficient taps as needed for pressure transducers, sample taps, dewatering, etc.

7. All isolation valves of four-inch diameter or greater on headers and laterals shall be butterfly valves.

F. Valves and Appurtenances on Yard Piping

1. Yard piping shall be of standard pipe size (i.e., 4-, 6-, 8-, 12-, 16-, 24-, 30-, and 36-inch diameter).

2. Locate valves for ease of access and operation.

3. Isolation valves shall be installed on piping entering and leaving the site to provide the ability to isolate the pumping station from the distribution system.

4. Underground valves from four- to twelve-inch in diameter shall be gate valves.

5. Underground valves from sixteen- to thirty-inch in diameter shall be either gate valves or butterfly valves.

6. Underground valves thirty-six-inch in diameter and larger shall be butterfly valves.

7. A sample spigot shall be provided from the discharge side of the pumps. The sample tap should be located on the pumping station site, just prior to entry into the water distribution system.

2.4 Hydropneumatic Tanks

A. Design Requirements

1. There are various methods for sizing the components of hydropneumatic pressure tanks. For the surge suppressant component, acceptable methods include, but are not limited to:

   a. "Hydro-Pneumatic Pressure Systems," Peerless Pump Company
   b. "Hydro-Pneumatic Tanks," Redcoat Reports

2. Regardless of the method used, the following parameters shall be considered:

   a. Operating Pressure Range
   b. Pumping Rate
   c. Water Seal over the tank outlets
   d. Pumping Cycles per Hour

3. Standard tank sizes are 1,500, 3,000, and 5,000 gallon. Specific tank sizing shall be performed for any pumping station with operating pressure in excess of 175 pounds per square inch, or a flow rate of greater than 5,000 gallons per minute.

4. Refer to Section 8-06 for additional design requirements.
5. No portion of the hydropneumatic tank shall be buried.
6. Protective coatings shall be NSF approved for potable use.

7. Specifications shall include tank capacity, dimensions, appurtenances, pressure rating, disinfection procedures, and air compressor capacity.

B. Tank Appurtenances

1. Tanks shall have isolation valves such that they can be isolated from the rest of the pumping station.

2. Tanks shall be equipped with an air compressor and shall be automated to maintain proper water and air volumes within the tank. Additional items include a stilling well and magnetic switches for air compressor controls, and for low suction alarm.

3. Tanks shall also be equipped with:
   - a pressure relief valve
   - a pressure gauge
   - a bottom drain and valve to completely drain the tank.
   - An access port for personnel entry to perform inspections.

4. Tanks shall be equipped for installation of a pressure pedestal.
5. Tanks shall have two lifting lugs on top of each tank.

8-10.3.0 Pressure Reducing Station Requirements

3.1 General Design Requirements

This subsection contains the following topics:

- Station Layout and Size
- Pressure Reducing Station Minimum Capacity
- Piping Size
- Above-Ground Valves
- Station Bypass

A. Station Layout and Size

1. Layout
   The pressure reducing station shall be an above-ground installation and shall be located within a secure enclosure. Tucson Water, Plant Design Section has sample layouts available.

2. Site Size
   The pressure reducing station site shall be of sufficient size to accommodate future installation of a magnetic flow meter, pressure transducers, and remote monitoring equipment.

B. Pressure Reducing Station Minimum Capacity
The minimum capacity of the pressure reducing station shall be 125% of the planned water demand. The water demand condition will be determined based on Section 8-06 of these standards.

C. Piping Size
Piping shall be sized to accommodate existing and future demands as described in Section 8-06 of these Design Standards.

D. Above-Ground Valves
All above-ground isolation valves shall be butterfly valves.

E. Station Bypass
The pressure reducing station shall be equipped with a bypass to allow continued service downstream during maintenance and repair activities. The minimum bypass pipe size and present and future water demand shall be as provided in Section 8-06.

3.2 Operations

The pressure reducing station shall be adjustable from 30 to 300 pounds per square inch downstream pressure and shall conform to Tucson Water standard pressure zone requirements.

3.3 Variances

Exceptions or variances shall be submitted for approval to Tucson Water and will only be considered on a project specific basis.

8-10.4.0 Water Storage Facility Requirements

This subsection contains the following topics:

- Site Requirements
- Types of Water Storage Reservoirs
- Reservoir Design Requirements
- Piping Requirements
- Valves and Appurtenances
- Leakage Testing

4.1 Site Requirements

This subsection contains the following topics:

- Title of Property
- Site Conditions
- Site Access
- Site Surface
- Sanitary Control Distances
- Site Clearances
- Site Size and Shape
- Site Enclosures
- Site Drainage
- Site Elevation

A. Title of Property

The property for a storage facility will normally be conveyed in fee title to Tucson Water or the City of Tucson.

B. Site Conditions

The site shall meet at least one of the following conditions for access:

1. Have sixty feet or more of frontage directly along at least one public street having a right of way width of at least sixty feet.

2. Have an access easement of at least thirty feet in width from a public right of way to the site.

3. Access that has drainage problems, is unduly steep, or has other conditions that limit access will not be acceptable unless remediation of these problems is provided.

C. Site Access

Access shall be an all-weather road of not less than twelve feet in width, except that access roads, which exceed fifty feet in length, shall not be less than sixteen feet in width. An all-weather road will be defined as an improved surface with drainage improvements as required. Improved surface will be gravel, chip-seal, asphaltic concrete, or concrete as determined by Tucson Water.

D. Site Surface

Gravel surfacing of the interior of the site shall be required to provide reasonable access to all components of the pumping station.

E. Sanitary Control Distances
Sanitary control distances shall be as required by ADEQ.

F. Site Clearances
Sites being conveyed to Tucson Water or the City of Tucson shall comply with all requirements of the City of Tucson Real Estate Division, which includes, but may not be limited to, the following:

- Archaeological Clearance
- Environmental Site Assessment Clearance
- Biological Assessment Clearance

G. Site Size and Shape
The storage facility site shall be of a sufficient size and appropriate shape to allow for all equipment and any necessary maintenance and repair activities, but in no case shall it be less than 8,000 square feet. The narrowest side shall be not less than one-half the dimension of the widest side.

H. Site Enclosures
All sites shall be enclosed by an intruder resistant enclosure. The security enclosure shall be completely located within the property boundary of the site. Depending on the site location, an acceptable enclosure may be one of the following:

1. Chain link fencing with a minimum height of six feet of chain link fabric, with three strands of barbed wire on top, for total fence height of seven feet, minimum.

2. Masonry wall with a minimum height of seven feet.

3. One sixteen-foot (minimum) drive-through gate and one three-foot walk-through gate. Gates shall be of equivalent height as enclosure and shall be lockable.

I. Site Drainage
All sites shall be designed to allow for drainage of storm water and for any drainage of the pumping station for testing, maintenance, or repair.

1. Use drainage swales, curbs, culverts, storm sewers, or a combination thereof, as required, to provide internal site drainage.

2. If an offsite storm sewer or major drainage way is available, site drainage shall be collected before leaving the site.

3. The internal site collection system shall be sized to accommodate storm water as well as any additional water from testing of the pumping station or drainage for repairs.

J. Site Elevation
The site shall be located at an elevation that allows for provision of required Net Positive Suction Head to the pumping station, present or future.

4.2 Types of Water Storage Reservoirs

The type of reservoir will depend on various factors including but not limited to, size, location, environmental and neighborhood concerns.

A. Above-Ground Storage

1. Welded Steel Tank
   Welded steel tanks shall conform to the most current revision of AWWA D-100. In general, welded steel tanks will range from 10,000 gallons to 2.0 million gallons in capacity.

2. Bolted Steel Tank
   Bolted steel tanks shall conform to the most current revision of AWWA D-103. In general, bolted steel tanks will range from 10,000 gallons to 500,000 gallons in capacity.

3. Pre-Stressed Concrete Tank
   Pre-stressed concrete tanks shall conform to the most current revision of AWWA D-110. In general, pre-stressed concrete tanks will range from 250,000 gallons to 2.0 million gallons in capacity.

B. In-Ground Storage

1. Reinforced Concrete Reservoirs
   In general, Reinforced Concrete Reservoirs will range from 2.0 million gallons to 20.0 million gallons in capacity.

2. Pre-Stressed Concrete Reservoirs
   Pre-stressed concrete reservoirs shall conform to the most current revision of AWWA D-110. Pre-stressed concrete reservoirs will range from 250,000 to 2.0 million gallons in capacity.

4.3 Reservoir Design Requirements

This subsection contains the following topics:

- Above-Ground Storage
- In-Ground Storage

A. Above-Ground Storage

1. Provide one or more inlets for each reservoir. The inlet shall be located in the side wall of the tank and at least 45° from the reservoir outlet. The inlet may be located at the top or bottom of the tank wall depending on the system conditions or requirements.

2. On single reservoir installations, provide two outlets located at least 90° apart and at least 45° from a tank inlet. On multiple reservoir installations, the dual outlets will be required only on the first reservoir. On outlets which provide suction supply to station pumps, the outlet piping shall be equipped with an internal 90° fitting turned downward to prevent development of a vortex. The fitting shall be a ductile iron flange and flare; a ductile iron 90° long radius elbow; or a welded steel mitered fitting. Outlets shall have a minimum of twelve-inch clearance from the reservoir floor.

3. Provide an internal overflow weir inlet with an external overflow pipe. The overflow assembly shall be sized to handle the maximum tank influent rate with a maximum water level rise over the inlet weir of six-inches. The overflow discharge pipe shall terminate above ground, not be subject to submergence, and be fitted with a hinged flap valve or other approved check valve. The top of the overflow weir shall be a minimum of one-foot below the bottom of any roof rafter.

4. Provide one or more drains. The drains shall not be less than four-inch diameter and shall include an isolation valve. It shall be located a minimum practical distance above the tank floor. Alternatively, a flush-type drain in accordance with API 650, Section 3.7.8 may be used with Tucson Water approval. The drain may be connected to the overflow discharge pipe outside of the tank.

5. Provide one or more air vents located at or near the center of the roof, at the highest point practical. Vents shall be sized to prevent unacceptable atmospheric pressure changes for the maximum influent and effluent rates. Only the effective (net) screen opening area shall be considered for required airflow. Vents are to be double gooseneck type with the openings protected by 316 Stainless Steel Screen, 16 mesh.

6. Foundation:
   a. Welded Steel and Bolted Steel Tanks
      The tank shall be supported by compacted aggregate base course on compacted native soil. The top of the foundation shall be at least eight inches above finished grade of the yard. The compacted material shall be contained by a steel foundation ring or a reinforced concrete foundation ring as required by detailed design. Additional reinforced concrete pads may be required for center ring or columns as determined by detailed design. The tank floor shall be sloped downward at least one-inch vertical to every ten-feet horizontal from the tank center to the outside edge.

   b. Prestressed Concrete Reservoir
      The foundation shall be designed by a professional structural engineer registered in the State of Arizona, and the design shall be based on a site-specific geotechnical report.

7. Access
   a. Ladders

      - Provide an exterior ladder extending to the full height of the tank. The exterior ladder shall comply with all OSHA Standards including safety cage and landings as required.
      - Provide an interior ladder. The interior ladder shall be offset from the exterior ladder by at least two feet.

   b. Roof Guard Rails
      Provide hand rails along the roof edge for a minimum distance of ten feet on both sides of the exterior ladder and a minimum of five feet on both sides of any perimeter appurtenance.

c. Roof Hatch
The primary roof hatch shall have a minimum size of thirty-inches in diameter with a four-inch curb. The roof hatch shall have a hinged cover with a two-inch downward overlap and provisions for locking. The location shall be offset from the exterior ladder centerline over the interior ladder. A secondary roof hatch shall be located over the tank overflow.

d. Walkways
Provide non-skid walkways on the roof of steel tanks to allow safe access to any appurtenance.

e. Shell Manholes
- Welded Steel Tanks. Provide at least two shell manholes. One manhole shall be thirty inches in diameter with a hinged cover in accordance with AWWA Standards. The second manhole shall be a forty-eight-inch by forty-eight-inch flush-type cleanout in accordance with API Standards complete with hinge or davit arm. Locate the manholes approximately 180° apart.

- Bolted Steel Tanks. Provide two flush-type cleanouts in accordance with API Standards. Cleanouts shall be a minimum of twenty-four-inch wide by forty-eight-inches high and be located approximately 180° apart.

B. In-Ground Storage
1. Provide one inlet per reservoir located near the top of the reservoir and at the opposite side of the reservoir from the outlet.

2. Provide the reservoir outlet connection through an outlet structure at the bottom of the reservoir with a minimum four-inch silt stop.

3. Provide an internal overflow weir with an external overflow pipe or drainage channel. Size the overflow assembly to handle the maximum reservoir influent rate with a maximum water level rise over the weir of six inches.

4. Provide one drain with an isolation valve. Make drain connection through the bottom of the reservoir and terminate in an open top concrete drain box connected to a storm sewer system or adequate site drainage swale.

5. One or more vents, as necessary, shall be located at the highest point of the reservoir wall or at or near the highest point of the roof. The vents shall be sized for the maximum influent and effluent rates. Only the effective (net) screen opening shall be considered to pass air flow. Vents shall be of the gravity-type with openings protected by 316 Stainless Steel screen, 16 mesh.

6. The foundation shall be designed by a professional structural engineer registered in the State of Arizona and design shall be based on a site-specific geotechnical report.

7. Based on geotechnical report, existing environmental conditions, and Tucson Water's direction, a reservoir underdrain system and/or leak detection and monitoring system may be required.

8. Access
   a. Stairs/Ladders

      - Provide an exterior stairway or ladder extending to the roof of the reservoir.
      - Provide an interior stairway or ladder to access the interior of the reservoir.

   b. Roof Guard Rails
      Provide handrails according to OSHA standards along the edge of the roof.

   c. Roof Hatch

      - The primary roof hatch shall be a minimum of 2'-6" by 10'-0", with a four inch curb. The roof hatch shall have a hinged cover with a two-inch downward overlap and provisions for locking.

      - Additional roof hatches shall be required for sampling. These hatches shall be located at a minimum of one hatch centered over each quarter of the reservoir and shall be a minimum of eighteen inches square.

   d. Walkways
      Provide non-skid walkways on the roof to allow safe access to any appurtenance and to prevent damage to reservoir roof.

4.4 Piping Design

A. Materials
Piping shall be either standard steel pipe in accordance with ASTM A53 or ductile iron pipe in accordance with the requirements of Section 1401 of The Tucson Water Standard Specifications.

B. Piping Configuration
1. Water storage facilities shall be designed with a separate inlet and outlet. The inlet and outlet shall be configured to minimize detention time of water.

2. The piping for water storage facilities that include a pumping station will be configured to allow the pumps to operate with the reservoir isolated from its source of supply.

3. Water storage facilities that include a pumping station will have piping configured to allow bypass of water back to reservoir.

4. Piping shall be configured to allow for any planned future facilities. This may include additional reservoir or an additional pumping station or station upgrade.

4.5 Valves and Appurtenances

A. Isolation Valves

1. A manually operated valve will be provided on the reservoir outlet piping to provide isolation of the reservoir.

2. A motor-operated valve with remote-operating capability will be provided on the reservoir inlet piping.

3. Provide valves as required to isolate any major appurtenances to allow for future repair or replacement.

B. Control Valves

Provide control valves as required to allow for isolation of the reservoir with continued ability to use any associated pumping station and for isolation of any associated pumping station with continued ability to use the reservoir.

C. Appurtenances

Depending on system requirements, a flow meter may be required on the inlet and/or outlet of the reservoir. A staff gauge and water level indicator shall be provided to verify tank level on site.

4.6 Leakage Testing

All new reservoirs shall pass a leakage test prior to acceptance by Tucson Water. Testing requirements shall be clearly defined in the Contract Specifications, and shall conform to the latest industry standard for the type of reservoir being tested (i.e.: AWWA for welded or bolted steel tanks; ACI for reinforced concrete reservoirs.)

8-10.5.0 Water Production Well Equipping Requirements

This subsection for water production well equipping contains the following topics:

- Site Requirements
- Site Layout Design Requirements
- Piping, Valves and Appurtenances
- Pumping Units
- Pump Drivers

5.1 Site Requirements

This subsection contains the following topics:

- Title of Property
- Site Conditions
- Site Access
- Site Surface
- Site Surface
- Sanitary Control Distances
- Site Size and Shape
- Site Enclosures
- Site Enclosures
- Site Drainage

A. Title of Property

The property for a well site will normally be conveyed in fee title to Tucson Water or the City of Tucson.

B. Site Conditions

The site shall meet at least one of the following conditions for access:

1. Have sixty feet or more of frontage directly along at least one public street having a right of way width of at least sixty feet.

2. Have an access easement of at least thirty feet in width from a public right of way to the site.

3. Access that has drainage problems, is unduly steep, or has other conditions that limit access will not be acceptable unless remediation of these problems is approved by Tucson Water.

C. Site Access

Access shall be an all-weather road of not less than twelve feet in width, except that access roads, which exceed fifty feet in length, shall not be less than sixteen feet in width. An all-weather road will be defined as an improved surfacing with drainage improvements as required. Improved surfacing will be gravel, chip-seal, asphaltic concrete, or concrete as determined by Tucson Water.

D. Site Surface
Gravel surfacing of the interior of the site shall be required to provide reasonable access to all components of the pumping station.

E. Sanitary Control Distances
Sanitary control distances shall be as required by ADEQ.

F. Site Clearances
Sites being conveyed to Tucson Water or the City of Tucson shall comply with all requirements of the City of Tucson Real Estate Division, which includes, but may not be limited to, the following:

- Archaeological Clearance
- Environmental Site Assessment Clearance
- Biological Assessment Clearance

G. Site Size and Shape
The pumping station site shall be of a sufficient size and appropriate shape to allow for all equipment and any necessary maintenance and repair activities, but in no case shall it be less than 14,450 square feet. The narrowest side shall be not less than one-half the dimension of the widest side (85 feet x 170 feet, minimum).

H. Site Enclosures
All sites shall be enclosed by an intruder resistant enclosure. The security enclosure shall be completely located within the property boundary of the site. Depending on the site location, an acceptable enclosure may be one of the following:

1. Chain link fencing with a minimum height of six feet of chain link fabric, with three strands of barbed wire on top, for total fence height of seven feet, minimum.

2. Masonry wall with a minimum height of seven feet.

3. One eighteen-foot (minimum) drive-through gate and one three-foot four inches walk-through gate. Gates shall be of equivalent height as enclosure and shall be lockable.

I. Site Drainage
Sites shall allow for drainage of storm water and for any drainage of the pumping station for testing, maintenance, or repair.

1. Use drainage swales, curbs, culverts, storm sewers, or a combination thereof, as required, to provide internal site drainage.

2. If an offsite storm sewer or major drainage way is available, site drainage shall be collected before leaving the site.

3. The internal site collection system shall be sized to accommodate storm water as well as any additional water from testing of the pumping station or drainage for repairs.

5.2 Site Layout Design Requirements

This subsection contains the following topics:

- Well Location
- Location of Appurtenances
- Encroachments and Obstructions
- Aboveground Clearances
- Discharge Piping

A. Well Location

Locate the well a minimum of forty feet from the water production facility enclosure (wall or fence, etc.) at the point of access. Provide a thirty-two foot by forty-five foot open area on the quadrant of the well site as indicated in Exhibit 10-1 for laying out column piping during pump repair.

B. Location of Appurtenances

See Exhibit 10-1 for a well site general arrangement. The location of control buildings, hydropneumatic tanks, transformers, and any other appurtenances shall remain clear of the open area.

C. Encroachments and Obstructions

No site boundary, public street right-of-way, utility easement, or power company aerial easement shall encroach on the area within forty feet in front of the well and twenty feet on either side of the well. No physical obstructions on the site shall be within this area.

D. Aboveground Clearances

With the exception of well discharge piping, all plant equipment, fences, plant structures, and aboveground piping shall be at least thirty feet from wells.

E. Discharge Piping

See Exhibit 10-1. Where space permits, locate well discharge piping at a right angle to the direction of well access opposite the open area.

5.3 Piping, Valves and Appurtenances

This subsection contains the following topics:

- Piping General
- Fabrication of Steel Pipe Requirements
- Ductile Iron Pipe and Materials
- PVC Pipe and Materials
- Piping System Design Requirements

A. Piping General

1. The piping shall be designed so that the well will discharge directly into the system or a reservoir.

2. Wells with a direct connection into the distribution system shall be disinfected according to ADEQ and Tucson Water requirements.

3. The aboveground discharge piping shall be fabricated steel or mill type standard steel pipe in accordance with ASTM A53.

4. The below-ground discharge piping shall be fabricated steel pipe, mill type standard steel pipe, ductile iron pipe, or PVC pipe.

5. The aboveground discharge piping shall include piping, check valves, butterfly valves, flex couplings, flow meters, test tees, and other above ground discharge piping appurtenances required for a complete installation. See Exhibit 10-2 for a typical aboveground discharge piping detail.

6. The discharge piping shall be sized for proper operation of the check valve and water meter. Normal velocities should be five feet per second.

7. Put a sample tap and an air release valve before the check valve.

8. Put a pressure gauge between the check valve and flow meter.

9. Put a length of ten pipe diameters of straight pipe leading into the flow meter and a minimum length of five pipe diameters of straight pipe downstream of the flow meter or install in accordance with the meter manufacturer's recommendations, whichever is greater.

10. Provide a well test tee downstream of the flow meter.

B. Fabrication of Steel Pipe Requirements

1. Steel pipe shall be fabricated steel pipe or mill type standard steel pipe in accordance with ASTM A53.

2. The minimum wall thickness shall be as follows:

a.	Less than 5-inch diameter:	Schedule 40
b.	6 to 10-inch diameter:	3/16 –inch
c.	12 to 14-inch diameter:	7/32 –inch
d.	16 to 42-inch diameter:	1/4 -inch
e.	48 to 60-inch diameter:	3/8 –inch
f.	66 to 72-inch diameter:	1/2 -inch

3. Fittings
   a. Flanges shall be Class 125 in accordance with ANSI B16.1 for operating pressures up to 250 pounds per square inch. For operating pressures above 250 pounds per square inch, flanges shall be Class 250 in accordance with ANSI B16.1.

   b. Above-ground fittings shall be flanged, welded, or coupled. Nuts and bolts shall be hot dip galvanized steel or epoxy painted.

   c. Below ground fittings shall be welded or coupled. Nuts and bolts shall be grade 316 stainless steel.

   d. Gaskets shall be butyl or EPDM.

4. Protective Coating
   a. Internal coating shall be a three-coat, two-component catalyzed epoxy system which shall conform to all NSF requirements for potable water service. The minimum thickness shall be 12.0 dry mils, but in no case shall any individual coat be less than 4.0 nor more than 7.0 dry mils.

   b. External coating for above-ground service shall be a two-coat, two-component epoxy system or a polyurethane system. The thickness of this coating system shall be 6.0 - 9.0 mils. The first coat shall be between 4.0-6.0 dry mils, and the second coat shall be between 2.0-3.0 dry mils.

   c. External coating for below-ground service shall be a factory-applied polyurethane system.

C. Ductile Iron Pipe and Materials
1. Ductile iron pipe shall conform to the requirements of Section 1401 of the Tucson Water Standard Specifications.

2. Fittings
   a. Flanges shall be Class 125 in accordance with ANSI B16.1 for operating pressures up to 250 pounds per square inch. For operating pressures above 250 pounds per square inch, flanges shall be Class 250, ANSI B16.1.
   b. Nuts and bolts shall be grade 316 stainless steel.
   c. Gaskets shall be Grade 1 rubber or Buna N.

D. PVC Pipe and Materials
PVC Pipe and fittings shall conform to the requirements of Section 1404 of the Tucson Water Standard Specifications.

E. Piping System Design Requirements
1. The discharge piping shall be sized for proper operation of the check valve and flow meter. Normal velocities shall not exceed five feet per second.

2. Thrust Restraint
   a. Design thrust restraint is required for all above and below-ground installation.

   b. Use restrained joints, welded joints, or joint harnesses for thrust restraint. Reaction blocking and anchors will only be allowed for special conditions as approved by Tucson Water.

   c. Design for flexible couplings to allow expansion, contraction, and maximum serviceability of equipment. Flexible couplings shall be designed to provide a restrained joint.

3. Corrosion control of below-ground metallic pipe shall be in conformance Section 8-11 of these Design Standards.

4. Layout and Clearances
   a. Yard piping shall be located in areas accessible for maintenance and repair.

   b. Clearance between waterlines and sanitary sewers shall conform to the requirements set forth by ADEQ.

5.4 Pumping Units

A. Pumps General

1. Pumps may be either line shaft driven vertical turbine or submersible.

2. The pump capacity shall be such that the run time shall be a minimum of two hours.

3. A pump may be installed in a well that has a design capacity greater than the rated capacity of the pump.

4. The pump should have adequate submergence to allow a pumping level decline for approximately seven-years based on historic regional decline data in the area.

5. The pump curve for the pump shall be as steep as practicable, and shall exhibit a continuously rising characteristic to shut-off head, with no points of zero slope reversal. The pump bowl's efficiency shall be as high as practicable.

6. The pump performance shall be measured at the pump discharge.

B. Line Shaft Driven Vertical Turbine Pumps

1. Vertical turbine well pumps shall be capable of operating at 150% of design head or shut-off head, whichever is less, for not less than two minutes without excessive vibration, binding, rubbing of rotating parts, or damage to the pump.

2. The column pipe assembly shall consist of column pipe, oil tube, line shaft, couplings, bearing and oil tube centralizing stabilizers (spiders). The inner-column (oil tube, line shaft, couplings and bearings) shall be manufactured to Johnston new style standard dimensions and threading.

3. The column pipe and inner column shall be sized to have a column velocity of +/- 5 feet per second at the design point. The column pipe shall be furnished in interchangeable sections of a nominal length of ten feet.

C. Submersible Pumps

Submersible pump construction shall conform to the requirements of Section 1204 of the Tucson Water Standard Specifications.

5.5 Pump Drivers

A. Electric Motors

1. Electric motors shall be three-phase, 480 volt.

2. Size electric motors to carry the full load of the well pump without using the motor service factor.

3. Motor enclosures may be open drip-proof, WP-1 or totally enclosed fan-cooled.

4. Motors of fifty horsepower or more shall have reduced-voltage starting.

5. Provide an anti-reverse ratchet or timer lockout for all vertical turbine pumps. Should the ratchet fail during normal operation, the motor will not start until reverse rotation has stopped. The timer lockout shall provide for two delays in series.

6. In all cases, provide a timer on the well motor start circuit to prevent starting of the well within 300-seconds of shutdown.

7. Motors should be selected to allow compliance or modification for compliance with the City of Tucson and Pima County noise ordinances.

B. Natural Gas Engines

1. Natural gas engines are generally used at remote locations where sound would not be a problem for neighbors.

2. A concrete engine base shall be designed to contain oil spills, or engine crankcase ruptures.

3. A shade structure shall be installed to protect the engine and related hardware.

4. The engine shall be cooled by a dual-wall heat exchanger system.

8-10.6.0 Electrical, Instrumentation and Control Requirements

6.1 Power

A. Electric Service

1. Electric service for Tucson Water facilities shall be designed for actual connected and future loads. Method for sizing service entrance shall comply with Institute of IEEE and NEC guidelines.

2. Service shall be designed for three-phase, 480 volts where available. Single phase power and other service voltages may be acceptable depending upon Tucson Water facilities requirements.

3. Location of the service transformer and meter/current transformer may be either on or off Tucson Water property depending upon Tucson Water water plant requirements. Conduits and service conductors shall be adequately sized for the designed load and shall meet electric utility design standards, National Electric Code and applicable codes.

4. Service meter and current transformers shall be provided by the electric utility. Connection of service entrance equipment and startup shall be coordinated between Tucson Water representatives and contractor and appropriate electric utility personnel.

B. Electrical Distribution System

1. Electrical equipment on the load side of the meter/current transformer shall be owned and operated by Tucson Water.

2. Site layout, electric room general arrangement and power distribution equipment shall be designed to minimize voltage drop, provide operation and maintenance ease and accessibility and meet space requirements in accordance with NEC guidelines.

3. Electrical distribution system may consist of a single or multiple three-phase 480 or 120 volt service disconnect(s) and 480/120 volt power distribution equipment.

4. Distribution equipment may consist of motor control centers or pump panels, circuit breakers and/or fused disconnect switches, motor starters, 480-240/120 volt service transformers, wireway and/or conduit, etc.

5. Distribution system and equipment shall be designed to adequately supply the design load and shall be in accordance with National Electric Code, National Electrical Manufacturers Association, IEEE and applicable codes and practices.

6.2 Instrumentation and Control

A. Process Control and Instrumentation
Process control and instrumentation at Tucson Water facilities may be local and remote with manual override capabilities or local with manual override capabilities depending upon site. Process control and instrumentation equipment shall be selected for use within manufacturers recommended guidelines.

B. Field Devices
Field devices shall be located on or near piping and reservoir roofs and consist of pressure and/or flow switches/sensors, flow meters, level sensors and switches, transmitters, actuators, etc. Field devices shall be designed and calibrated to meet site specific flow, level and pressure ranges, etc.

C. Motor Control Circuitry
Motor control circuitry shall be located in a motor control center or pump panel enclosure, which can be either in the field or electric room. Motor control center or pump panel shall be sized to provide adequate space for motor power and control circuitry.

D. Control and Instrumentation Compatibility
All control and instrumentation shall be compatible with and routed through a PLC located in a station control panel either indoors or outdoors, which is used for controlling and/or monitoring the site.

E. Communications and SCADA
Communications and SCADA shall use radio or leased lines depending on facility water plant requirements.

8-10.7.0 Disinfection Requirements

Tucson Water will determine the requirements for disinfection systems on a case by case basis.

If a disinfection system is required based on Tucson Water's determination, the system will be designed to accommodate the specific needs of the water system.

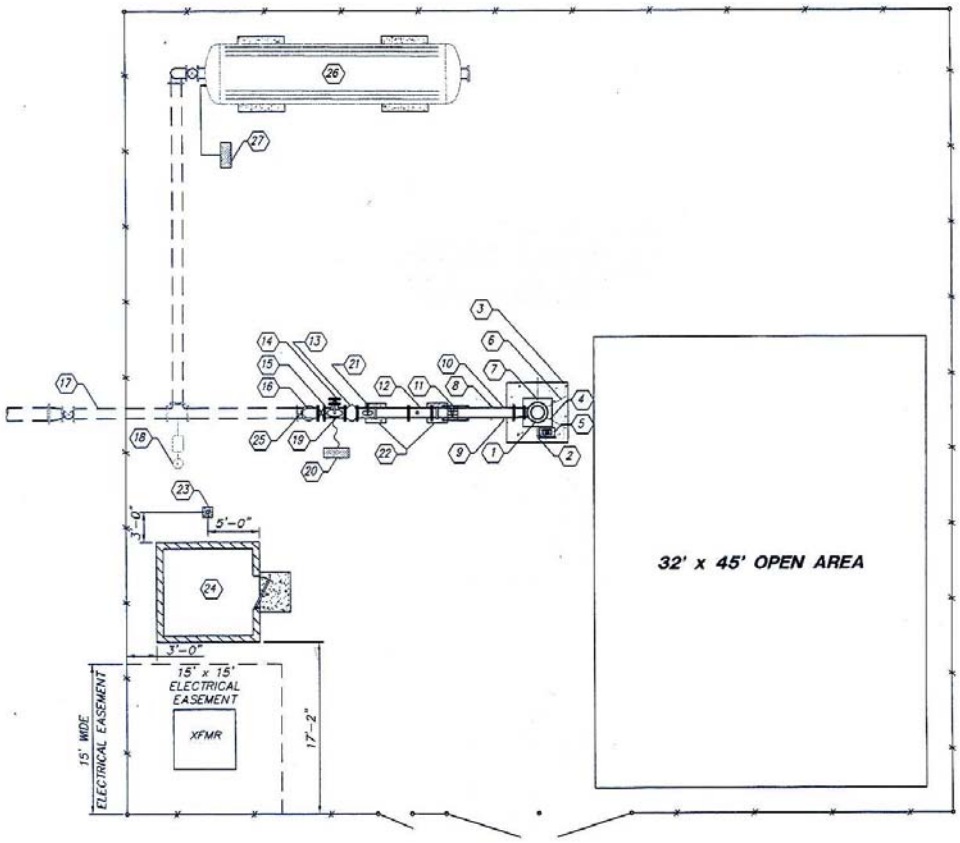
All disinfection systems will be designed by Tucson Water.

8-10.8.0 Exhibits

Exhibit 10-1, Example Site Layout of Typical Pumping Station
Exhibit 10-2, Example of Typical Above-Ground Discharge Piping Detail

Exhibit 10-1, Example Site Layout of Typical Pumping Station

EXAMPLE SITE LAYOUT (ILLUSTRATION 1)

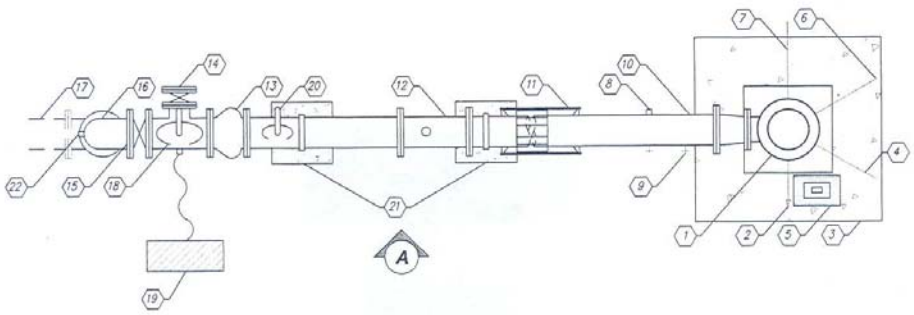


PIPING & EQUIPMENT

1. PUMP & MOTOR
2. GRAVEL FILL TUBE
3. 6' x 6' CONCRETE WELL BASE
4. WATER LEVEL SENSING DEVICE
5. OIL RESERVOIR
6. SOUNDING TUBE
7. SCREEN VENT
8. 3/4" THRED-O-LET ON HOIZ ℄ W/PLUG
   3/4" THRED-O-LET ON HORIZ ℄ (OPPOSITE SIDE) CORPORATION, HOSE BIBB & VACUUM BREAKER
9. 3/4" THRED-O-LET ON HORIZ ℄ W/ 3/4" CORPORATION & SAMPLE PLAIN END FAUCET
10. STANDARD STEEL SPOOL PIECE (S.S.S.P.)
11. FLEX COUPLING & HARNESS ASSEMBLEY
12. FLOWMETER
13. CHECK VALVE
14. TEST TEE W/BUTTERFLY VALVE & BLIND FLANGE
15. BUTTERFLY VALVE
16. 90° BEND, VERTICAL W/ 1" THRED-O-LET & CORP.
    S.S.S.P., VERTICAL
    90° BEND, VERTICAL
17. BELOWGROUND PIPING
    NOTE: ALL UNDERGROUND PIPE SHALL BE INSTALLED WITH RESTRAINED JOINTS.
18. SAMPLE FAUCET
19. 3" THRED-O-LET & BALL VALVE ON TOP OF TEST TEE
20. PRESSURE CONTROL ASSEMBLY, BASE & PEDESTAL
21. 2" THRED-O-LET ON TOP VERTICAL ℄ W/2" COMBINATION AIR RELEASE VALVE
22. PIPE SADDLE SUPPORT
23. ANTENNA
24. CONTROL BUILDING
25. 1" THRED-O-LET & CORPORATION ON VERTICAL S.S.S.P. FOR DISINFECTION
26. HYDRO TANK
27. AIR COMPRESSOR

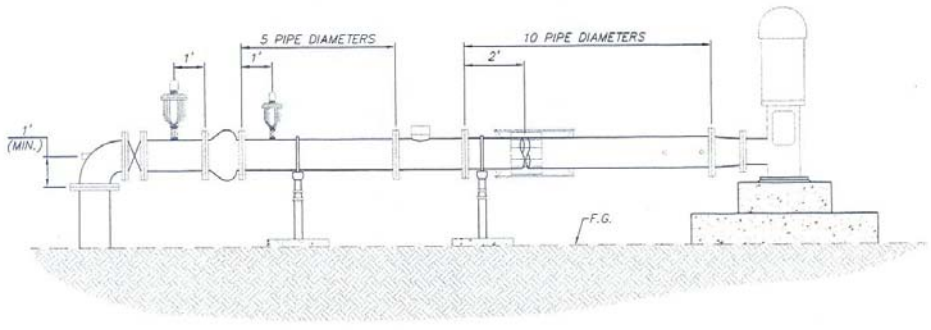
Exhibit 10-2, Example of Typical Above-Ground Discharge Piping Detail

EXAMPLE ABOVE-GROUND DISCHARGE PIPING DETAIL (ILLUSTRATION 2)



PIPING & EQUIPMENT

1. PUMP & MOTOR
2. GRAVEL FILL TUBE
3. 6' x 6' CONCRETE WELL BASE
4. WATER LEVEL SENSING DEVICE
5. OIL RESERVOIR
6. SOUNDING TUBE
7. SCREEN VENT
8. 3/4" THRED-O-LET ON HOIZ ℄ W/PLUG
   3/4" THRED-O-LET ON HORIZ ℄ (OPPOSITE SIDE) CORPORATION, HOSE BIBB & VACUUM BREAKER
9. 3/4" THRED-O-LET ON HORIZ ℄ W/ 3/4" CORPORATION & SAMPLE PLAIN END FAUCET
10. STANDARD STEEL SPOOL PIECE (S.S.S.P.)
11. FLEX COUPLING & HARNESS ASSEMBLEY
12. FLOWMETER
13. CHECK VALVE
14. TEST TEE W/BUTTERFLY VALVE & BLIND FLANGE
15. BUTTERFLY VALVE
16. 90° BEND, VERTICAL W/ 1" THRED-O-LET & CORP. S.S.S.P., VERTICAL
    90° BEND, VERTICAL
17. BELOWGROUND PIPING
    NOTE: ALL UNDERGROUND PIPE SHALL BE INSTALLED WITH RESTRAINED JOINTS.
18. 3" THRED-O-LET & BALL VALVE ON TOP OF TEST TEE
19. PRESSURE CONTROL ASSEMBLY, BASE & PEDESTAL
20. 2" THRED-O-LET ON TOP VERTICAL ℄ W/2" COMBINATION AIR RELEASE VALVE
21. PIPE SADDLE SUPPORT
22. 1" THRED-O-LET & CORPORATION ON VERTICAL S.S.S.P. FOR DISINFECTION



SECTION A-A