LAKE HAVASU CITY

Community Investment Department

Sewer Design Standards

Prepared By

Lake Havasu City, Arizona

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Lake Havasu City

Sanitary Sewer Design Standards and Specifications

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1.0 DESIGN STANDARDS

1.1 General Requirements

A sanitary sewage collection system includes all sewer lines and associated structures, devices, and appurtenances, including but not limited to, sewer mains, laterals, manholes, and pump stations. All construction shall be in accordance with Lake Havasu City Standard Specifications and Details

A. Compliance with Arizona Administrative Code

All sanitary sewage collection systems shall be designed and constructed in accordance with these Standards, Lake Havasu City standard specifications and details, and the Arizona Administrative Code R18-9-E301.4.01. The requirements of the Arizona Administrative Code may be modified by the State of Arizona for Lake Havasu City. These modifications shall be noted within these Standards.

Where these Standards differ from the Arizona Administrative Code, the Arizona Administrative Code shall govern unless these Standards are stricter or the requirements of the Arizona Administrative Code have been modified by the State of Arizona for Lake Havasu City as noted within these Standards.

B. Compliance with ASCE's Report No. 69

All sanitary sewage collection systems constructed within the Lake Havasu City Wastewater Service Area are to be designed in compliance with the information contained within this document and must adhere to ASCE's Report no. 69, Sulfide in Wastewater Collection and Treatment Systems.

C. General Criteria

The design criteria shall be applied to all components of a sanitary sewage collection system.

A sanitary sewage collection system shall be designed, constructed, and operated in order to:

1. Provide adequate wastewater flow capacity for the service;
2. Minimize sedimentation, blockage, and erosion through maintenance of proper flow velocities throughout the system;
3. Prevent sanitary sewer overflow through appropriate sizing, capacities, and inflow and infiltration prevention measures throughout the system;
4. Protect water quality through minimization of exfiltration losses from the system;
5. Provide for adequate inspection, maintenance, testing, visibility, and accessibility; and
6. Maintain system structural integrity.
7. Minimize Hydrogen Sulfide

1.2 Basis of Design Flows

A. Per Capita Flow

The system shall be designed in accordance with the following currently accepted criteria:

1. Residential …… 80 gallons per capita per day

All other non-residential facilities shall be based on Arizona Department of Environmental Quality Administration Code, Title 18, Chapter 9, and Table 1. Unit Design Flows.

The sewer design flows are based on the land use plan value of 2.47 persons per single family dwelling, number of residential dwellings at build out, and the build out acreage of non-residential areas (i.e., commercial, industrial, etc.). The variances in the above values are realized by converting non-residential users to equivalent residential connection

1.3 Design Factors

Sanitary sewage collection systems shall be designed for the ultimate tributary population, based on topography and the Wastewater Master Plan's Study Area. Information concerning the ultimate tributary population can be obtained from the most recently updated adopted version of the Lake Havasu City General Plan and the Lake Havasu City Wastewater Master Plan, Phase II, copies of which are available at the office of the City Engineer.

Consideration shall be given by the designer to the maximum anticipated capacity of institutions, industrial parks, residential subdivisions, etc.

Additional consideration shall be given by the designer to the following factors:

1. Maximum hourly sewage flow.
2. Topography of the area to be sewered.
3. Location of the flow discharge.
4. Depth of excavation.
5. Need for pump stations.
6. Minimum flows/sedimentation.
7. Odor control.

A. Peaking Factors

The design flow is calculated as average flow times peaking factor. The table below indicates the peaking factor as required by the Arizona Administrative Code, dated January 1, 2001. Designer shall conform with all future changes by the Arizona Department of Environmental Quality to the peaking factors in Table 1.0 as shown below.

Table 1.0 - Peaking Factors

Upstream Population	Peaking Factor
100	3.62
200	3.14
300	2.90
400	2.74
500	2.64
600	2.56
700	2.50
800	2.46
900	2.42
1000	2.38
1001 to 10,000	$PF= (6.330 \times p^{-0.231}) + 1.094$
10,001 to 100,000	$PF= (6.177 \times p^{-0.233}) + 1.128$
More than 100,000	$PF= (4.500 \times p^{-0.174}) + 0.945$

PF = Peaking Factor
p = Upstream Population

Other widely used relationship of flow from moderate sized domestic sewage areas is as follows:

Maximum Daily Flow = Peaking Factor x Average Daily Flow

B. Depth of Excavation

Grinder pumps are not allowed on LHC projects. If grinder pumps are used on private developments, all grinder pumps will be maintained exclusively by the private property owners at their expense.

All gravity sewer lines and force mains shall have a minimum of three feet of cover over the top of the pipe. Consideration shall be given by the designer to prevent the need for gravity sewer lines at depths greater than sixteen feet that may present undue maintenance problems if repairs are required. The designer shall compare the construction cost of additional excavation versus the construction and O&M cost of a pump station/force main system and submit the information to the City Engineer or his designee for consideration for any proposed lines with depths in excess of sixteen feet.

Provide the maximum cover attainable, and construct the sewer line with restrained-joint pvc pipe concrete encased. The designer shall insure that the design of the pipe and joints can withstand crushing or shearing from any expected load, and shall take additional measures to prevent damage to the sewer line, such as concrete encasement or other means of protection.

If a sewer line crosses a drainage channel, place the sewer line a minimum of two feet below the 100-year storm scour depth. Scour analysis in these areas must be done and shall meet all ADEQ requirements. All sewer lines, both gravity and force mains, shall be constructed using restrained-joint C900 pipe with a concrete cap. Concrete caps and restrained-joint C900 pipe shall extend at least 10 feet beyond the boundary of the drainage channel scour width, where a concrete straddle block shall be installed around the pipe at both ends.

The Sewer Design Standards & Specifications limit the depth of sanitary sewers to 20 feet. With good intent, this reduces the potential for maintenance difficulties associated with deep sewers. However, if sewers constructed at depths greater than 20 feet eliminate the need for a sewage pumping station the extra depth maybe allowed.

C. Trenching and Backfill

Per Lake Havasu City Standard Specification Section 02300 – Trench Excavation and Backfill.

1.4 Gravity Sanitary Sewers

A. Minimum Size

Ensure that each line is 8 inches in diameter or larger except the first 400 feet of dead end sewer line with no potential for extension may be 6 inches if the design flow criteria meets the specified flow requirements. See section R-18-9-E301.4.01D.2.d of the Arizona Administrative Code.

Sanitary sewage force mains shall be sized in accordance with the criteria specified in Section 2.10, Sanitary Sewage Force Mains, of this document.

No individual service connection, or service lateral, shall be less than 4 inches in diameter.

All industrial, municipal lots, etc. service connections, or service laterals, shall be a minimum of 6 inches in diameter.

B. Pipe Material

All 4-inch and larger gravity sanitary sewer pipes shall be constructed of SDR 35 Polyvinyl Chloride (PVC) gravity sewer pipe meeting ASTM D3034.

C. Acceptance Testing of Gravity Sanitary Sewers

All gravity sanitary sewer mains shall be tested in accordance with the Arizona Administrative Code. All acceptance testing shall be performed in the presence of the City Engineer or authorized representative. Testing shall consist of the following:

1. **General Information**
   Test each section of gravity pipeline for leakage and pressure rating after backfilling occurs. Perform leakage tests with the air test as specified below. Test laterals from the main line to property line.

2. **Field Pressure Tests**
   Perform field pressure tests as described below.

3. **Deflection Test for PVC Pipe**
   In addition to pressure and leakage testing, a deflection test shall be performed on all gravity pipelines installed. A rigid ball or mandrel deflection testing equipment and labor shall be provided. Test shall be performed without mechanical pulling devices.

   Any section of the pipeline which shows deflection in excess of 5 percent of the average inside diameter as per ASTM D3034 shall be removed and replaced at the Contractor's expense.

   Engineer may require Contractor to test PVC pipe after backfill has been in place for 30 days.

   After acceptance but prior to the termination of the specified warranty period, the Owner may test the long term deflection of the pipelines. Unless a longer warranty period is specified by City code or in a development agreement, a minimum warranty period of one year is required for the development or project area as a whole. If the Owner determines that the deflection exceeds 7.5 percent of the average inside diameter at any point in the pipeline, that portion of the pipeline shall be repaired or replaced by the Contractor at no cost to Owner.

4. **Video Inspection**
   The Owner will require the Contractor to video record the interior of the sewer line using a video camera. Any defects or 'sags' in the pipe or construction methods revealed by the inspection shall be corrected by the Contractor at no additional cost to the Owner.

   The Contractor shall re-video the pipe after it has been repaired or excavated. Any additional inspection(s) required, based on a failure or deficiency discovered during the inspection, shall be paid for by the Contractor. All sewer line videos shall be turned in to the City's Public Works Department or Engineering Department after acceptance.

5. **Air Testing**
   Perform air tests per F1417 for plastic mainline pipe sizes up to and including 42 inches in diameter, and will include lateral pipes to the property lines where applicable.

   Contractor shall furnish all facilities required including:

- Necessary piping connections.
- Test pumping equipment.
- Pressure gauges or manometers.
- Bulkheads.
- All miscellaneous items required.

Obtain approval of equipment and acceptance of methods proposed for use. Conduct initial test on first section of pipe laid by each crew.

- Include a minimum of 10 lengths of pipe but not to exceed 500 feet.

- Test remaining pipe in sections from manhole to manhole and have test approved by City Engineer or authorized representative.

- A wetted interior pipe surface on clay pipe is desirable and will produce more consistent test results.

- Plug ends of line and cap or plug all connections to withstand internal test pressures. Test plugs must be securely braced within the manholes.

- Introduce low-pressure air until internal air pressure is 4.0 psi. If groundwater is present in the area, the pressure shall be 4.0 psi greater than the average back pressure of ground water above the pipe invert.

- Allow two to five minutes for internal air pressure and temperature to stabilize. Adjust pressure to 3.5 psi and start test.

- The time required for the pressure to decrease 1.0 psi from 3.5 to 2.5 psi greater than the average back pressure of any ground water above the pipe invert shall not be less than the minimum test time in the following table for the given diameters:

Minimum Test Times in Plastic Pipe

Nominal Pipe Diameter	Time (min) per 100 ft.
4 inches	0.6
6 inches	1.4
8 inches	2.5
10 inches	3.9
12 inches	5.6
15 inches	8.9
18 inches	12.8
21 inches	17.1
24 inches	22.6
27 inches	28.8
30 inches	35.3
33 inches	43.2
36 inches	51.5

**** For 3.5 kPa (0.5 psi) pressure test drop, required test times shall be exactly one-half the values shown.***

If the section of line to be tested includes more than one pipe size, calculate the test duration for the length of each size and add the test durations to arrive at the total duration of the testing period for the section. Repeat test as necessary after all leaks and defects have been repaired.

1.5 Slope of Gravity Sanitary Sewers

A. Minimum Slope

The minimum slope of any gravity sanitary sewage line shall be calculated from Manning's Formula to meet the ADEQ flow velocity of 2.0 fps when the pipe is flowing full. Flow velocity for 6-inch pipe is 3.0 fps.

The following table summarizes the minimum slopes for various pipe sizes based on the above calculations.

Table 2.0 – Minimum Slopes

Pipe Size	Minimum Slope (ft/ft)
6"	0.0110
8"	0.0034
10"	0.0025
12"	0.0020
15"	0.0015

18”	0.0012
21”	0.0010
24”	0.00077

B. Maximum Slope

The maximum slope of any gravity sanitary sewage line shall be calculated from Manning’s Formula using a coefficient of roughness of 0.013 to meet the maximum flow velocity of 10.0 fps.

All gravity sanitary sewer mains shall have a constant slope from manhole to manhole. Vertical curvature shall not be allowed.

1.6 Location of Gravity Sanitary Sewers

Gravity sanitary sewers, including all gravity sewers and force mains, shall be located within a public right-of-way, whenever possible. However, individual laterals shall not be installed in a PUE in the location of a gravity sanitary sewer section.

When a public right-of-way is not available, or does not follow the necessary alignment of the gravity sanitary sewer, the designer shall utilize an existing public utility easement or publicly-owned parcel wherever possible. If necessary, the designer may utilize a horizontal alignment that requires a new easement be obtained. The designer shall advise Lake Havasu City that said easement is required, shall provide all legal descriptions and maps necessary to obtain said easement, and obtain said easement on behalf of Lake Havasu City. 0 feet wide for pipes less than twelve inches in diameter unless otherwise approved. Pipes twelve inches and larger shall require sufficient width for equipment to install, remove, or maintain the pipe, but in no instance less than 20 feet in width. This applies to all gravity sanitary sewers constructed within easements, with the exception of service lines, and all manholes with locking lids.

Gravity sanitary sewers shall be generally located along the centerline of the public right-of-way or easement. Where necessary to avoid conflicts with existing utilities, gravity sanitary sewers can be located in an area on one side of the right-of-way centerline, but within the right-of-way. Gravity sanitary sewers must be separated from potable water lines and reclaimed water lines.

1.7 Alignment of Gravity Sanitary Sewers

A. Horizontal

Gravity sanitary sewers shall be straight between manholes, unless a curvilinear alignment provides significant cost savings. In this instance, a curvilinear alignment shall be used with a minimum radius of 220 feet. The City Engineer or his designee shall make the final determination to use a curvilinear alignment on a case by case basis.

B. Vertical

All gravity sanitary sewer mains shall have a constant slope from manhole to manhole. Vertical curvature shall not be allowed.

C. Separation from Potable Water & Reclaimed Water

In accordance with Arizona Administrative Code R18-5-502.C, potable water and sewer mains shall be separated in order to protect public water systems from possible contamination. Sewer mains shall not be placed within 6 feet, horizontal distance, and within 2 feet, vertical distance, below the bottom of a water main unless extra protection is provided. Extra protection shall consist of encasing both the sewer and water mains in at least 6 inches of concrete for at least 10 feet beyond both sides of the water main. At no time will sewer be placed within 2 feet horizontal or 2 feet above water supply pipes.

When gravity sewer systems contain pressure components, the minimum separation between force mains or pressure sewers and water mains shall be 2 feet vertically and 6 feet horizontally under all conditions. Where a sewer force main crosses above or less than 6 feet below a water line, the sewer main shall be encased in at least 6 inches of concrete for 10 feet on either side of the water main.

Separation of sewer mains from reclaimed water systems shall abide by the above rules.

Separation of sewer mains from potable water lines and reclaimed water shall be in accordance with the details provided in Appendix A.

D. Separation from Utilities and Structures

Separation of gravity sanitary sewer mains from other utilities (gas, electric, telephone, etc) shall be a minimum of 10 feet unless otherwise approved. Fiber optic and TV cables shall have a minimum of 2 feet separation from gravity sewer mains.

Separation of gravity sanitary sewer mains from all structures, both above and below ground shall be a minimum of 10 feet unless

otherwise approved. Installation shall not exceed the minimum radius specified by the pipe manufacturer.

The City Engineer or his designee may review locations where the above separations can not be adhered to, and may allow a variance from the above separations on a case by case basis, provided that the minimum separation specified in the Arizona Administrative Code R18-5-502.C is always met.

1.8 Manholes and Appurtenances

A. Manholes

Manholes shall be installed at all changes of slope, all changes in pipe size, all changes in alignment, at all sewer intersections, and at an interval of no more than 500 feet between any two manholes.

When a smaller gravity sanitary sewer main flows into a larger gravity sanitary sewer main, the invert of the smaller sewer shall be raised sufficiently to maintain the same hydraulic grade line. This can be acceptably approximated by placing the crown of both pipes at the same elevation, but in no case shall the difference in flow line inverts be less than 0.2 feet. The hydraulic grade line shall be calculated from the anticipated full flow capacities of both pipes.

A drop manhole is defined as a manhole with an inlet invert that is 2 feet or greater than the outlet invert. Any manhole with an inlet/outlet invert less than 2 feet should have the base channels formed with concrete which allows for uniform flow and minimal corrosive gas. Drop manholes shall be constructed in accordance with the standard details provided in Appendix A.

Manholes shall be constructed from pre-cast concrete sections. Manholes shall have a pre-cast concrete base. The interior surface of all manholes, including bases, shall be smooth, uniform and self-cleaning.

The interior of manholes constructed of pre-cast concrete, meeting any of the criteria listed below, shall have a coating system as manufactured by Polymorphic Polymers Corporation **(**PPC), Life Last Coating System, or approved equal.

- Drop Manholes,
- First Manhole downstream of a Drop Manhole,
- Interceptors,

- Any manhole with more than one inlet and more than one outlet,
- Any manhole where severe changes in direction occur, as deemed necessary by City.
- First manhole downstream of force main connection.

Manholes shall be a minimum of 4 ft in diameter. The designer shall be responsible for coordinating with City for specific instances when larger manholes may be required.

Manholes with a depth of less than 8 feet from base to top of cover (measured at center of manhole**)** shall be defined as a shallow manhole and shall have a flat top instead of cone top.

Cone sections for manholes constructed from pre-cast concrete section with a depth equal to or greater than 8-feet from base to top of cover shall be eccentric and be oriented with the flow line with opening downstream.

Manholes shall not have steps or ladders.

Manholes shall have a minimum of 0.2 foot drop between inverts.

The angle between the flow line in and flow line out at any manhole shall not be less than 90 degrees unless otherwise approved. Manholes with a flow change in direction of 90 degrees or more shall be coated.

All pipe penetrations shall have waterstops, Ram-Nek seals, or other approved pipe gaskets to prevent leakage. All manhole sections shall be joined together using a plastic or mastic joint compound as recommended by the pre-cast manufacturer.

1. Frame and Cover

Frame and cover shall conform to ASTM A48, Class 30. The cover and frame will be a locking, non-ventilated type for all locations in non-paved areas and easements, and non-locking, non-ventilated type in paved areas, unless otherwise indicated.

The word "Sewer" shall be cast into the top of the lid along with the Lake Havasu City logo. The bearing surfaces of the frames and covers shall be machined and the cover shall bear firmly on a gasket mounted in the frame without rocking. Frame and cover shall be painted or dipped in commercial quality asphaltic paint.

Provide a concrete collar around the frame of each manhole cover. The collar shall have an inside diameter equal to the ring diameter at finished grade, an outside diameter two feet greater than the inside diameter, and a minimum thickness of 8 inches. The concrete collar shall be bedded on 6 inches of 3/8 inch crushed rock. A minimum of four contraction joints, at 90 degrees intervals, shall be placed in the concrete collar.

Provide one ("T" Handle Type) for 24-inch manhole frame and cover for each locking unit.

Acceptable Manufacturers (or approved equal):

a. Neenah Foundry Company
   Model R-1772 Cast Iron Manhole Frame & Cover with solid lid.

b. Model GTS as manufactured by Pout-a Mousson Everett Enterprises, Inc.

c. East Jordan Iron Works – Product no. 00102214 Catalog No. 1022Z3

d. Or approved equal

2. Use of Pre-Manufactured Manholes

The use of pre-manufactured fiberglass manholes is not allowed. The Environmental Protection Agency strongly advises against the use of these because of the potential for hazard.

3. Acceptance Testing of Manholes

All manholes shall be tested in accordance with the Arizona Administrative Code. All manhole testing must be conducted in the presence of the City Engineer or authorized representative. Testing can also be accomplished by air pressure testing using the "Standard Test Method for Concrete Sewer Manholes by Negative Air Pressure (Vacuum) Test" – ASTM C1244 as described below.

a. Plug all pipes entering the manhole, taking care to securely brace the plug from being drawn into the manhole.

b. Place the test head inside of the top of the cone section and inflate seal in accordance with the manufacturer's recommendations.

c. Draw a vacuum of 10 inches of mercury (4.9 psig) and shut off the vacuum pump. With valves closed, measure the time for the vacuum to drop to 9 inches of mercury (4.4 psig). The manhole shall pass if the time for the vacuum to drop is greater than 60 seconds for 48-inch diameter manholes, 75 seconds for 60-inch diameter manhole and 90 seconds for 72-inch diameter manholes.

d. If the manhole fails the initial test, make necessary repairs with a non-shrink grout. Retest and repair until a satisfactory test is obtained.

B. Service Laterals

All 4-inch and larger gravity sanitary sewer pipes shall be constructed of SDR 35 Polyvinyl Chloride (PVC) gravity sewer pipe meeting ASTM D3034.

No individual service connection, or service lateral, shall be less than four inches in diameter.

All industrial, municipal lots, etc. service connections, or service laterals, shall be a minimum of six inches in diameter.

Connection of the laterals to the main sewer shall be by the installation of a wye fitting in the main sewer. A standard gasket joint wye shall be installed at each service or future service on a new sewer main. Wyes for future services shall be located, to the degree possible, 10 feet from the property line between laterals at the lower side of the lot. In cases where a lot has no readily identifiable low side, wyes for future services shall be installed 10 feet from the property line between laterals nearest the downstream side of the sewer main.

Any service line with horizontal directional changes which add up to 45 degrees or greater will have a cleanout placed immediately upstream from the first fitting. If distance between fitting to fitting is greater than 10 feet, an additional clean out will be required. Installation of cleanout shall point toward the downstream flow.

Backwater valves shall be installed and tested per the International Plumbing Code. The backwater valves shall be installed approximately 5 feet from the right of way line on residential property.

On existing sewer mains, a saddle wye or InsertaTee shall be installed at every new service.

1.9 Package Stations and Pump Stations

The following table summarizes the difference between a Personal Package Station, Neighborhood Pump Station, Community Pump Station, and a Regional Pump Station in Lake Havasu City:

*Per City Council, Personal Package Pump Stations are not allowed on City projects.

Table 3.0 – Pump Stations

	Personal Package Station	Neighborhood Package Station	Community Pump Station	District Pump Station	Regional Pump Station
Approx No. Homes	1	3 to 24			
Rated Capacity			<10,000 gpd	10,000-100,000 gpd	≥100,000 gpd
Pump Type	Single Grinder	Dual Grinder	Dual Non-Clog	Dual Non-Clog	Dual Non-Clog
Force Main Size	< 4 inch	< 4 inch	< 4 inch	≥ 4 inch	≥ 4 inch
Flow Meter Required	No	No	No	Yes	Yes
Generator Required	No	No	No	Yes	Yes
CMU Wall Required	No	No	No	No	Yes
By-Pass Required	No	No	No	No	Yes
SCADA Required	No	Yes	Yes	Yes	Yes

All Pump Stations with a maximum capacity greater than or equal to 100,000 gpd (80 gpm) shall require SCADA, shall have perimeter CMU screen wall and gates, and by-pass for emergency pumps. All equipment, materials, and instruments shall be of a manufacturer approved by LHC and in accordance with the City's technical specifications.

All stations shall be designed, to the degree practical, for the maximum and minimum flows, present and future, for the gravity sanitary sewage collection system tributary to the station and shall be protected from physical damage or inundation during the 100-year flood.

A. Components

Package Stations shall be pre-fabricated systems with an integral wet well, pump, controls, and other appurtenances.

Pump Stations shall consist of a wet well, valve vault, electrical panel and other electrical controls, submersible pumps, piping and valves, and miscellaneous appurtenances. Flow meters and vault, emergency electrical generator, SCADA equipment, and CMU screen wall and gates shall be required as indicated in above Table. See also Preferred Manufacturers list for specific component manufacturers acceptable to Lake Havasu City.

1. **Wet Well**

   The standard wet well design for non-packaged Pump Stations shall be a reinforced concrete (cast-in-place) wet well sized appropriately for the specific volume of the Pump Station installation.

   Each wet well shall have aluminum hatches of the size recommended by the pump manufacturer. Aluminum hatches shall have a locking arm to hold hatches in open position and a hasp to allow the use of a padlock to prevent unauthorized entry or vandalism. No recessed locking mechanisms shall be allowed unless hatch is placed on streets or walkways, in which case a recessed hasp lock shall be provided. The hatches shall provide sufficient clear space to allow removal of the pumps and equipment without the need to remove the hatches or station lid.

   All equipment and materials located in the wet well, with the exception of the discharge piping, shall be 316 stainless steel.

   Each concrete wet well shall be coated in the field with a protective coating system on the inside. Acceptable coating systems are PPC, Lifelast, or approved equal.

2. **Valve Vault**

   The discharge piping from the pumps, including all check valves, isolation valves, and pressure gauges, shall be located within a reinforced concrete (cast-in-place) valve vault adjacent to the wet well. No valves, gauges, or appurtenances shall be allowed in the wet well.

   Each Valve vault shall have aluminum hatches of a size necessary to allow complete access to the discharge piping and valves. Aluminum hatches shall have a locking arm to hold hatches in open position and a hasp to allow the use of a padlock to prevent unauthorized entry or vandalism. No recessed locking

mechanisms shall be allowed unless hatch is placed on streets or walkways, in which case a recessed hasp lock shall be provided. The hatches shall provide sufficient clear space to allow removal of equipment without the need to remove the hatches or valve vault lid.

3. Use of Pre-Fabricated Components

Upon the approval of the City Engineer or his designee, the designer may utilize a pre-fabricated wet well with separate valve vault. A circular pre-cast concrete pipe may be used for the wet well. A pre-cast rectangular vault may be used for the valve vault.

Both pre-fabricated and cast-in-place construction should be bid as alternates. Pre-cast concrete wet wells shall be factory-coated on the inside and touched up in the field after installation with PPC, Lifelast, or equal.

4. Electrical Panel

The electrical service, panel and connections shall be designed in accordance with the adopted National Electric Code.

Pump station electrical service requirements shall be based on the existing electrical power availability at site and the needs of the most appropriate pump selection for the flow conditions anticipated. Electrical power service requirements are typically 240/120 VAC 1-phase, 208/120 VAC 3-phase, or 480 VAC 3-phase.

All pump stations shall have manual and automatic control mechanisms to control the start/stop of the pumps.

All pump stations shall have audible and visual high level alarm. The high level alarm shall also be connected to the SCADA system (except for individual service grinder pump stations) to alert operators of the alarm.

All electrical panel, controls, and all electrical accessories shall be protected from the sunlight by a structural steel screen at least 6-feet wide and long enough to cover the length of the electrical panels. The service levels for electrical equipment, especially pertaining to heat build-up and UV exposure must be considered in the final design. A concrete slab shall be used for the foundation and as a walkway in front of the panels. A structural engineer licensed in Arizona shall design the screen and base slab.

Site plan must show the wet well, electrical enclosure and SCADA panel be shown in reference to existing structures, easements, drainage ways, infrastructure, etc

5. Electrical Generator

An electrical generator shall be provided at each sewer Pump Station with a maximum capacity greater or equal to 10,000 gallons per day. The generator shall be sized to operate all lights and controls and start both pumps. Generators shall be designed to operate on natural gas where available. Where natural gas is not available generators shall be designed to operate on diesel fuel and shall have sufficient fuel storage to operate for a 24-hour period.

6. SCADA Equipment

The SCADA System shall transmit pump station alarm and pump status to the Existing Master Telemetry Unit at the Island WWTP via radio communication. Each new lift station shall have a programmable logic controller (PLC) based Remote Telemetry Unit (RTU) and radio. See SCADA System Design Standards for specific requirements.

The RTU will receive electrical signals from the lift/pump station control panel. Signals required for a typical duplex lift station are as follows: (Provide data points consistent for other pumping configurations.)

a. Lead Pump running (digital)
b. Lag Pump running (digital)
c. Lead Pump failure (digital)
d. Lag Pump failure (digital)
e. Wet Well high level (digital)
f. Wet Well low level (digital)
g. Wet Well level indicator (analog)
h. Generator Running (as required) (digital)
i. Generator Failure (as required) (digital)
j. Automatic Transfer Switch position (as required) (digital)
k. Flow signal (as required) (analog)

Other signals as required by specific pump station requirements (analog or digital) such as motor winding temperature, seal integrity, etc. shall be coordinated with the SCADA Supervisor.

All of the above signals will terminate in a termination cabinet prior to being connected to the SCADA system controller and radio.

Radio signals are to be broadcast via a local antenna mast with antenna oriented to reliably transmit signals to the Island Wastewater Treatment Plant's main antenna. All systems must communicate with the Lake Havasu City SCADA System. Radio communication shall be via existing 175MHZ band licensed radio system. Radio equipment shall match existing equipment as Manufactured by Esteem. The antenna shall be installed to provide reliable radio communication to the master radio. Depending on location and site conditions, the antenna shall be ¼ wave omni directional, ½ wave omni directional, or ½ wave Yaggi directional. The contractor shall be responsible to provide the appropriate antenna to achieve proper signal strength for each new location.

The SCADA RTU shall be PLC based with an Allen Bradley Micrologics PLC to match existing equipment. Provide white double **w**all enclosure with sunshade (air gap) to match existing. Provide power supply and battery backup operation.

The existing Master RTU and Master computer shall be programmed to accept the additional points for each new lift station. Modify existing computer graphics and software to accommodate new points. Provide a record backup copy of the new software configuration.

7. Pumps

Community, District, and Regional Pump Stations - Pumps shall be submersible, non-clog sewage pumps. All non-clog pumps shall be capable of passing a 3 inch solid.

Neighborhood Package Stations – Dual Grinder pumps shall be used for package pump stations.

Personal Package Stations **–** A Single Grinder pump shall be used for package pump stations.

General - Pumps shall be selected based on the head conditions and flow expected for specific areas to be served.

A minimum of two pumps shall be provided at all lift/pump stations, with the exception of personal package stations. Each pump in any station shall be capable of pumping the design flow and head.

8. Piping and Valves

All valves, fittings, and appurtenances shall be flanged or mechanical-joint PVC or 316 stainless steel, except that flanged items shall only be allowed inside of the wet well and valve vault. No direct burial of flanged fittings shall be allowed. Any piping to be submerged shall be 316 stainless steel. Exposed piping shall be coated in accordance with Section LHC 09900-Protective Coatings.

Discharge piping shall be C900/C905 PVC pipe and have restrained joints as necessary to resist thrust. Ductile Iron Pipe is not allowed for the construction of sewer force mains, unless otherwise specified.

Each pump shall have a separate suction and discharge line. Connection of the pump discharge lines shall be after all valving, and prior to any required flow metering.

Check valves shall be of the swing type, with an outside lever and weight, or the ball-check type. Check valves shall be installed in the horizontal position in the valve vault with adequate room to allow for easy maintenance and removal. Shut-off valves shall be provided on each individual pump discharge in the valve vault. Shut-off valve types shall be a plug valve, eccentric plug valve, or ball valve.

Valves shall be provided to isolate all mechanical devices requiring routine maintenance. (e.g. meters, check valves, etc.)

Fittings shall be installed to facilitate connection of a temporary pump in the event of pump failure at Regional Pump Stations.

9. Flow Meters

Regional Pump Stations shall have a flow meter.

Flow meters shall be magnetic flow meters. Flow meter system shall consist of a flow element and an indicating transmitter mounted remotely from the meter tube assembly. The flow meter system shall be accurate to within 1 percent of flow rate for velocities between 3 and 30 feet per second.

Flow meter body shall be constructed from 304 stainless steel tube with flanged ends. Flanged ends shall be Pressure Class 150 steel with flange pattern matching the adjacent piping. Electrodes shall be 316 stainless steel and conical shaped for self-cleaning. Flow meter body shall be lined with polyurethane.

Flow meter transmitter shall have "DC" excited coils. The flow meter transmitter electronics shall be microprocessor based, and shall accept the millivolt input from the meter and provide a 4-20 mA linear output signal proportional to flow.

A stainless steel grounding ring on the inlet and outlet shall be provided.

Acceptable manufacturers:

a. Brooks Instrument Division, Emerson Electric Company.
b. The Foxboro Company.
c. Honeywell Process Control Division.
d. Rosemount Inc.
e. Great Lakes Instruments.
f. Approved equal.

Flow meters shall be located within a vault as shown in the details in Appendix A.

Flow meters shall be connected to the SCADA system to provide real-time flow data.

10. Odor Control

Each Pump Station shall be designed and constructed to provide or capability to have odor control equipment installed. Station shall include provisions to add a chemical tank, chemical feed pump, discharge line to wet well, flow meter and controls. Design shall also include provisions, space, and electrical supply to provide for future simple installation of a chemical scrubber to remove odor from the volume of air in the wet well.

Initial station construction shall include the provision for the addition of odor controlling chemicals to the wet well to minimize odors at the station and downstream of the station.

11. CMU Screen Wall

A CMU screen wall consisting of split-face block shall be provided around the perimeter of each Community and Regional pump station (refer to LHC Standard Detail 26A).

CMU screen wall shall be a minimum of 8 feet tall.

A 24 feet wide double-swing gate shall be provided to allow vehicular access. A 3 feet personnel gate shall also be provided. All Gates shall be manufactured from wrought iron and shall have

provisions for locking by padlock. All walls and gates shall be in accordance with the detail in Appendix A.

Design of CMU screen wall shall be accomplished by a structural engineer registered in the State of Arizona. Further security options for pump stations include video security cameras, intrusion detection and motion sensors should be analyzed on a per pump station design basis.

12. Emergency Pump By-Pass

Fittings shall be installed to facilitate connection of a temporary pump in the event of an emergency. The pump connection shall be a cam-lock or similar fitting with a manual isolation valve to isolate the fitting from the pipe system.

1.10 Sanitary Sewer Force Mains

A. Pipe Materials

All sanitary sewer force mains 4 inches and greater shall be constructed of Polyvinyl Chloride Pipe (PVC) C900/905. Sanitary sewer force mains 4-inches and smaller shall be constructed of high density polyethylene (HDPE) pipe or C900 PVC.

Force mains shall be designed to flow full under all conditions and with a minimum flow velocity adhering to the design standards listed on page 26 of this document. An engineering analysis shall be performed for each force main to achieve full flow conditions were possible at the listed minimum suggested velocities of three feet per second.

The designer shall calculate the required thrust restraint at all changes in horizontal and vertical alignment. Adequate thrust restraint shall be provided by the means of restrained-joints. Location and details of restrained-joints shall be shown on the construction plans. Where restrained-joint pipe is required, the designer shall require the use of one of the following joint restraints:

1. U.S. Pipe - TR Flex
2. EBAA Iron Inc. – Megalug
3. Griffin Pipe Products – Snap-Lok

B. Alignment

Unless prior approval is received from the City Engineer or designee, horizontal locations of sanitary sewer force mains should at all times

be located a minimum of 5 feet from the nearest edge of a right-of way or easement.

When a public right-of-way is not available, or does not follow the necessary alignment of the sanitary sewer force main, the designer shall utilize an existing public utility easement or publicly-owned parcel where ever possible. The designer may utilize a horizontal alignment that requires that a new easement be obtained. The designer shall advise Lake Havasu City that said easement is required, shall provide all legal descriptions and maps necessary to obtain said easement, and obtain said easement on behalf of Lake Havasu City. Easements shall be a minimum of 20 feet wide unless otherwise approved for pipes less than twelve inches in diameter. Pipes twelve inches and larger shall require easements of sufficient width for equipment to install, remove, or maintain the pipe but in no instance less than 20 feet in width. All sanitary sewer force mains constructed within easements shall be constructed of PVC, and all manholes and vaults shall have locking lids.

Sanitary sewer force mains shall be generally located where necessary to avoid conflicts with existing utilities. The sanitary sewer force mains can be located in an area on one side of the right-of-way centerline, but within the right-of-way. Sanitary sewer force mains must be separated from potable water lines and reclaimed water lines in accordance with these Standards.

The minimum cover over a sanitary sewer force main shall not be less than 4 feet. The maximum cover over a sanitary sewer force main shall not be greater than 10 feet except in locations approved by the City Engineer or his designee. However, this should be based upon what is required after the scour analysis has been performed. The top of the pipe will need to be at least 2 feet below the calculated scour depth.

The vertical alignment of force mains should follow the topography in order to minimize excavation. Sanitary sewer force mains shall grade continuously uphill, if at all possible, to prevent accumulation of air at high points. Air release/vacuum valves shall be incorporated into force mains at all necessary high points along the line to eliminate air accumulation. Air release/vacuum valves shall be designed and located by a certified Engineer to eliminate the possibility of corrosion attack. Where installation of such valves is necessary, the valve shall be installed in a pre-cast concrete vault, properly vented, with provisions for temporary back flushing without cross connections. All connecting hardware for air release/vacuum valves shall be 316 stainless steel.

The designer shall provide isolation valves along the alignment of the force main. Isolation valves shall be plug valves, and shall be at an interval not to exceed 2,000 feet.

C. Velocities

Per ADEQ, the minimum velocity in a sanitary sewer force main shall be 3 feet per second.

Per ADEQ the maximum velocity in a sanitary sewer force main shall be 7 feet per second.

D. Separation from Potable Water & Reclaimed Water

In accordance with Arizona Administrative Code R18-5-502.C, potable water and sewer mains shall be separated in order to protect public water systems from possible contamination. Sewer main shall not be placed within 6 feet, horizontal distance, and within 2 feet, vertical distance, below the bottom of a water main unless extra protection is provided. Extra protection shall consist of encasing both the sewer and water mains in at least 6 inches of concrete for at least 10 feet perpendicular distance beyond both sides of the water main.

The minimum separation between sanitary sewer force mains and water mains shall be 2 feet vertically and 6 feet horizontally under all conditions. Where a sanitary sewer force main crosses above or less than 6 feet below a water line, the sanitary sewer force main shall be encased in at least 6 inches of concrete for 10 feet perpendicular on either side of the water main.

Separation of sanitary sewer force mains from reclaimed water systems shall abide by the above rules.

Separation of sanitary sewer force mains from potable water lines and reclaimed water shall be in accordance with the standard details provided in Appendix A.

E. Separation from Utilities and Structures

Separation of sanitary sewer force mains from other utilities (gas, electric, telephone, cable television, fiber optic, etc.) shall be a minimum of 10 feet.

Separation of sewer mains from all structures, both above and below ground, shall be a minimum of 10 feet.

The City Engineer or his designee may review locations where the above separations cannot be adhered to, and may allow a variance from the above separations on a case by case basis.

F. Acceptance Testing of Sanitary Sewage Force Mains

Perform hydrostatic pressure and leakage tests on all sections of sanitary sewer force main. The City Engineer or his authorized representative shall witness pressure and leakage test. Testing shall conform to AWWA C600 or C900/905 procedures, as modified herein. Testing shall be performed after backfilling, but before final replacement of pavement.

Test separately in segments between sectionalizing valves, between a sectionalizing valve and a test plug, or between test plugs. Select test segments such that adjustable seated valves are isolated for individual checking. All anchors, braces, and other devices to withstand hydrostatic pressure on plugs shall be installed.

Limit fill rate of line to available venting capacity. Fill rate shall be regulated to limit velocity in lines when flowing full to not more than 1.0 fps. Owner shall make water for testing available to Contractor at nearest practical source.

Pressure and Leakage Test Procedure:

1. Test pressure shall not be less than 50 psi greater than the working pressure at the highest point along the test section.
2. Test shall be at least 2-hour duration. Maintain pressure throughout test +5 psi of test pressure.
3. Leakage test shall be conducted concurrently with the pressure test.
4. Acceptable when leakage does not exceed that determined by the following formula (in English units):

   $L = 0.0000075\ SD(P)^{1/2}$, in which

   L = allowable leakage, in gallons per hour

   S = length of pipe tested, in feet

   D = nominal diameter of the pipe, in inches

   P = average actual leakage test pressure in psig
5. These formulas are based on an allowable leakage of 11.65 gpd/mile/in of nominal diameter at a pressure of 150 psi.
6. When testing against closed metal-seated valves, an additional leakage per closed valve of 0.0078 gal/hr/in of nominal valve size shall be allowed.
7. Repair any deficiencies and repeat test as necessary until satisfactory performance of test.

8. All visible leaks are to be repaired regardless of the amount of leakage.

All work shall be done in accordance with the Arizona Administrative Code and ADEQ

1.11 Effluent Reuse Pump Stations and Force Mains

A. Effluent Reuse Pump Stations

1. Electrical Panel

The electrical service, panel and connections shall be designed in accordance with the currently adopted National Electric Code.

Pump station electrical service requirements shall be determined by existing electrical power availability at site and the most practical pumps for the conditions anticipated at the station. Electrical power service requirements are typically 240/120 VAC 1-phase, 208/120 VAC 3-phase, or 480 VAC 3-phase.

All effluent pump stations shall have manual and automatic control mechanisms to control the start/stop of the pumps.

All effluent pump stations shall have audible and visual high level alarm. The high level alarm shall also be connected to the SCADA system to alert operators of the alarm.
The electrical panel, controls, and all electrical accessories shall be protected from sunlight by a structural steel screen at least 6 feet wide and long enough to cover the length of the electrical panels. A concrete slab shall be used for the foundation and as a walkway in front of the panels. A structural engineer licensed in Arizona shall design the screen and base slab.

2. Electrical Generator

In general, electrical generator will not be required at effluent reuse pump stations. However, the engineer will evaluate the need for an electrical generator on a case-by-case basis.

If deemed necessary, generators shall be designed to operate on natural gas when gas lines are available in the area. When

natural gas is not available the generator shall be designed to operate on diesel fuel. The generator shall be sized to operate all lights and controls and start one pump and shall have sufficient fuel storage to operate for a 24-hour period.

3. SCADA Equipment

The SCADA system shall consist of a transmitter/receiver individual controller (programmable logic controller (PLC)) and radio units. See SCADA System Design Standards for specific requirements.

The PLC will receive all electrical signals generated by the effluent pump station. Signals generated by the various effluent pump stations will be both analog and digital signals. Minimum signals that are required are as follows:

a. Lead Pump running (digital)
b. Lag Pump running (digital)
c. Lead Pump failure (digital)
d. Lag Pump failure (digital)
e. Reservoir High Level (digital)
f. Reservoir Low Level (digital)
g. Generator Running (digital)
h. Generator Failure (digital)
i. Automatic Transfer Switch position (digital)
j. Flow signal (analog)
k. Other signals as required by specific pump station requirements (analog or digital) such as motor winding temperature, seal integrity, etc.

All of the above signals will terminate in a termination cabinet prior to being connected to the SCADA system controller and radio. Radio signals are to be broadcast via a local antenna oriented to reliably communicate with the Island Wastewater Treatment Plant main antenna.

The SCADA RTU shall be PLC based with an Allen Bradley Micrologics PLC to match existing equipment. Provide white double enclosure with sunshade/air gap to match existing. Provide power supply and battery backup operation.

Radio communication shall be via existing 175MHZ band licensed radio system. Radio equipment shall match existing equipment as Manufactured by Esteem. The

antenna shall be installed to provide reliable radio communication to the master radio. Depending on location and site conditions, the antenna shall be ¼ wave omni directional, ½ wave omni directional, or ½ wave Yaggi directional.

The existing Master PLC and Master computer shall be programmed to accept the additional points. Modify existing computer graphics and software to accommodate new points.

4. Pumps

Pumps shall be vertical turbine, end suction or horizontal split case pumps capable of pumping filtered effluent.

Pumps shall be selected based on the head conditions and flow currently existing and those anticipated based on the planned system improvements.

A minimum of two pumps shall be provided at all effluent pump stations.

Each pump at the effluent pump station shall be capable of pumping the design flow and head.

5. Piping and Valves

All piping, valves, fittings and appurtenances shall be flanged or mechanical-joint. Flanged fittings shall be allowed in valve vaults and wet wells, but shall not be allowed in direct bury conditions.

Discharge piping shall have restrained joints as necessary to resist thrust. Thrust blocks will not be considered as an alternative under normal conditions.

Each pump shall have a separate suction and discharge line. Connection of the pump discharge lines shall be after all valving, and prior to any required flow metering.

Check valves shall be swing check or rotary ball type.

Shut-off valves shall be provided on each individual pump discharge in the valve vault. Shut-off valve types shall be a gate valve or butterfly valve.

6. Flow Meters

Each pump station shall have a flow meter.

Flow meters shall be magnetic flow meters. Flow meter system shall consist of a flow element and an indicating transmitter mounted remotely from the meter tube assembly. The flow meter system shall be accurate to within 1 percent of flow rate for velocities between 3 and 30 feet per second.

Flow meter body shall be constructed from 304 stainless steel tube with flanged ends. Flanged ends shall be Pressure Class 150 steel with flange pattern matching the adjacent piping. Electrodes shall be 316 stainless steel and conical shaped for self-cleaning. Flow meter body shall be lined with polyurethane.

Flow meter transmitter shall have "DC" excited coils. The flow meter transmitter electronics shall be microprocessor based, and shall accept the millivolt input from the meter and provide a 4-20 mA linear output signal proportional to flow.

A stainless steel grounding ring on the inlet and outlet shall be provided.

Acceptable manufacturers:

a. Brooks Instrument Division, Emerson Electric Company.
b. The Foxboro Company.
c. Honeywell Process Control Division.
d. Rosemount Inc.
e. Great Lakes Instruments.
f. Approved equal.

Flow meters shall be located within a vault as shown in the details in Appendix A.

Flow meters shall be connected to the SCADA system to provide real-time flow data.

B. Effluent Reuse Force Mains

1. Pipe Materials

All effluent reuse force mains shall be greater than 4 inches in diameter. Effluent reuse force mains 4 inches to 12 inches shall be constructed of C900. For pipe sizes of 14 inches and greater, the designer shall specify the minimum pressure class necessary for the specific design based on laying condition, depth of bury, loads and other factors.

Designer shall calculate the required thrust restraint at all changes in horizontal and vertical alignment. Adequate thrust restraint shall be provided by the means of restrained-joints. Location and details of restrained-joints shall be shown on the construction plans. Where restrained-joint pipe is required, the designer shall require the use of one of the following (or "approved equal") joint restraints:

a. U.S. Pipe - TR Flex
b. EBAA Iron Inc. – Megalug
c. Griffin Pipe Products – Snap-Lok

2. Alignment

Effluent reuse force mains shall be located within a public right-of-way, whenever possible.

When a public right-of-way is not available, or does not follow the necessary alignment of the effluent force main, the designer shall utilize an existing public utility easement or publicly-owned parcel wherever possible. As a last resort, the designer may utilize a horizontal alignment that requires that a new easement be obtained. The designer shall advise Lake Havasu City that said easement is required, shall provide all legal descriptions and maps necessary to obtain said easement, and obtain said easement on behalf of Lake Havasu City.

Easements shall be a minimum of 20 feet wide unless otherwise noted for pipes less than twelve inches in diameter. Pipes twelve inches and larger shall require easements of sufficient width for equipment to install, remove, or maintain the pipe but in no instance less than 20 feet in width. All effluent force mains constructed within

easements shall be constructed of C900/905 PVC pipe, and all manholes and vaults shall have locking lids.

Effluent reuse force mains shall be located as necessary to avoid conflicts with existing utilities. The effluent reuse force main can be located in an area on one side of the right-of-way centerline, but within the right-of-way. Effluent reuse force mains must be separated from potable water lines, sanitary sewer mains, and sanitary sewer force mains in accordance with these Standards.

The minimum cover over any effluent reuse force main shall not be less than four feet. The maximum cover over any effluent reuse force main shall not be greater than ten feet except in locations approved by the City Engineer or his designee.

Effluent force mains shall grade continuously uphill, if possible, to prevent accumulation of air at high points. The vertical alignment of effluent force mains should follow the topography to the degree practical in order to minimize excavation.

Air/vacuum release valves shall be incorporated into effluent reuse force mains at all necessary high points along the line to eliminate air accumulation. Effluent force mains shall be laid at a grade that minimizes the need for air release/vacuum valves. Where installation of such valves cannot be avoided, the valve shall be installed in a pre-cast concrete vault, properly vented, with provisions for temporary back flushing without cross connections. All connecting hardware for air release/vacuum valves shall be 316 stainless steel.

3. Velocities

Per ADEQ, the minimum velocity in an effluent reuse force main shall be 3 feet per second.

Per ADEQ, the maximum velocity in an effluent reuse force main shall not exceed 7 feet per second.

4. Separation from Potable Water & Sanitary Sewer

Separation of reclaimed water systems from gravity sanitary sewers, sanitary sewer force mains, and potable water systems shall abide by the rules established in these Standards.

Separation of reclaimed water systems from gravity sanitary sewers, sanitary sewer force mains, and potable water systems shall be in accordance with the details provided in Appendix A.

5. Separation from Utilities and Structures

Separation of effluent reuse force mains from other utilities (gas, electric, telephone, cable television, fiber optic, etc.) shall be a minimum of 10 feet.

Separation of effluent reuse force mains from all structures, both above and below ground, shall be a minimum of 10 feet.

The City Engineer or his designee may review locations where the above separations cannot be adhered to, and may allow a variance from the above separations on a case by case basis.

6. Acceptance Testing of Effluent Reuse Force Mains

Perform hydrostatic pressure and leakage tests on all sections of effluent force main. The City Engineer or his designee shall witness pressure and leakage test. Testing shall conform to AWWA C600 or C900/905 procedures, as modified herein. Testing shall be performed after backfilling.

Test separately in segments between sectionalizing valves, between a sectionalizing valve and a test plug, or between test plugs. Select test segments such that adjustable seated valves are isolated for individual checking. All anchors, braces, and other devices to withstand hydrostatic pressure on plugs shall be installed.

Limit fill rate of line to available venting capacity. Fill rate shall be regulated to limit velocity in lines when flowing full to not more than 1.0 fps.

Owner shall make water for testing available to Contractor at nearest practical source.

Pressure and Leakage Test Procedure:

a. Test pressure shall not be less than 1.25 times the working pressure at the highest point along the test section.

b. Test shall be at least 2-hour duration. Maintain pressure throughout test +5 psi of test pressure.

c. Leakage test shall be conducted concurrently with the pressure test.

d. Line is acceptable when leakage does not exceed that determined by the following formula (in English units):

$L = 0.0000075\ SD(P)^{1/2}$, in which
L = allowable leakage, in gallons per hour
S = length of pipe tested, in feet
D = nominal diameter of the pipe, in inches
P = average actual leakage test pressure in psig

e. These formulas are based on an allowable leakage of 11.65 gpd/mile/in of nominal diameter at a pressure of 150 psi.

f. When testing against closed metal-seated valves, an additional leakage per closed valve of 0.0078 gal/hr/in of nominal valve size shall be allowed.

g. Repair deficiencies and repeat test as necessary until satisfactory performance of test.

h. All visible leaks are to be repaired regardless of the amount of leakage.

1.12 Sewer Flow Meters

A. Sanitary sewer flow meters may be installed in accordance with these regulations for the purpose of metering flow from an individual property that has metered water use of which a significant portion is not discharged to the public sewer system. The individual property

will be a large water user such as a wet industry, condominium/apartment complex, hotel or large commercial facility. The measured flow should also have a pipe velocity greater than 0.75 ft./sec.

B. A licensed plumbing contractor shall perform all plumbing work. All electrical work shall be performed by a licensed electrical contractor. All appropriate plumbing and electrical permits are required.

C. The metering equipment shall be an Ultrasonic Open Channel Flow Meter, Doppler radar type flow meter, a combination of both, or the latest technologically advanced flow meter on the market or approved equal. The installation of the metering equipment shall be as directed by the manufacturer and the Sewer Flow Meter detail included in Appendix A. The following options are required:

1. Digital LCD readout in gallons
2. Seven-digit non-resettable totalizer
3. Sufficient cable for proper installation

D. The metering equipment shall be installed in a Plasti-fab metering manhole or approved equal.

In addition, the following options are required on the manhole:

1. Traffic-rated lid
2. Stainless steel sonic bracket
3. Neoprene boots with stainless steel bands for 4-inch and larger pipe

F. Other methods of measurements may be allowed at the discretion of the City Engineer if the reliability and degree of accuracy of flow measurement of the proposed equipment can be shown to be equal to, or greater than, the system described above.

1.13 Plans and Specifications Requirements

A. Requirements

Gravity Sanitary Sewers, Lift Stations, Pump Stations, Sanitary Sewage Force Mains, & Effluent Reuse Pump Stations and Force Main designs shall adhere to the following:

1. Plans shall be reproduced on paper 24 inches by 36 inches (11” x 17” available on request).

2. Provide plan and profile drawings of proposed construction at a horizontal scale not to exceed 1 inch =50 feet and a vertical scale not to exceed 1inch =10 feet.
3. Be of sufficient detail to provide a clear understanding of the work to be constructed and shall be suitable for bidding by the City.
4. Shall show the horizontal and vertical location of all known utilities.
5. Show topographic contours.
6. Shall show all easements and rights-of-way.
7. Shall provide a vicinity map showing the location of the work to be constructed.
8. Shall show electrical equipment locations, electrical service, and single line diagrams.
9. Upon completion of design, and after approval from ADEQ and Lake Havasu City has been obtained; Provide Lake Havasu City with hard copy and electronic specifications and reproducible drawings of all plans, sections and details, plus electronic files of all drawings in AutoCAD, Release 2000 or newer.

Upon completion of construction, and after approval of construction by ADEQ, provide to Lake Havasu City as-built construction drawings of all plans, plus all pressure and leakage testing records, Engineer's Certificate of Completion, and all other documents related to project approval.

2.0 HYDROGEN SULFIDE ISSUES

Sewers constructed at minimum slopes and sewage pump stations and force mains produce long detention times. Higher ambient temperatures also facilitate odor generation. To eliminate corrosion possibilities, it is required that all future sanitary sewer force mains be designed and installed with C900/C905 PVC pipe.

Corrosion of exposed concrete or metal surfaces occurs from the bacterial oxidation of H_2S to sulfuric acid (H_2SO_4) under aerobic conditions in the presence of moisture and CO_2 in sewer systems which support the bacterial metabolism and carbon source respectively. Sulfuric acid is highly corrosive to the cement paste in concrete and is highly corrosive to steel. Therefore, it is recommended that that all future sanitary sewer force mains be installed with C900/C905 PVC pipe.

Odor Control and Corrosion Control - There are several options for controlling odor and some of the control methods are also effective in controlling corrosion. Vapor phase control can be accomplished by

biological filters or chemical scrubbers. These require varying levels of operation and maintenance and treatment is limited to off-gas vapors from a wet well or manhole. Liquid phase control can result in treatment of the odor and reduction of the potential for corrosion. Chemical costs may be optimized by utilizing liquid phase treatment and a vapor phase polish.

Sodium hypochlorite is one method available for liquid phase treatment. Lake Havasu City currently uses this method at the Aquatic Center Pump Station. The City has had very good success with the injection of Bioxide® at strategic locations in the system for larger sewage pump stations. The calcium nitrate in the Bioxide® acts as an oxygen source for the bacteria. Bacteria use the oxygen from the nitrate preferentially to using the oxygen from sulfate. This reduces the sulfide formation. The Bioxide® product is primarily recommended for larger pump stations where flows are higher.

Each new sewage pump station and the corresponding force main should be evaluated for the potential of odor generation and corrosion. The following items should be considered:

- Analysis of potential lengthy detention times
- The possibility of air entrainment in the force main
- Higher ambient temperatures encountered and its potential effect on the system

Vapor phase odor control should be included in all major pump stations. All pump stations shall be designed to provide for future chemical addition for liquid phase treatment. In general, the following guidelines should be followed in the design process:

- Maintain dissolved oxygen greater than 0.5 mg/l.
- Keep dissolved sulfide less than 0.1 to 0.3 mg/l, while 0.1 mg/l is preferred, it may be difficult and costly to achieve.
- Maintain hydrogen sulfide in the air at less than 3 to 5 parts per million (ppm).
- Increase pipe crown pH to 4.0 or higher.

All of the items stated above shall be addressed in the evaluation of pump stations and force main systems during design.

It is noted that current design standards achieve a 3-foot per second (fps) minimum velocity in force mains. With regard to odor control on short force mains, a velocity of 3 fps may be acceptable on certain sections of force main with high cycle times and resultant short detention times in the wet well and force main. However, on longer force mains, it is recommended that the minimum velocity for odor and corrosion control be adopted as shown in the following table.

Table 5.0 – Minimum Velocities

Force Main Size (in.)	Minimum Velocity (fps)	
	Typical Wastewater	Heavy Grit Wastewater
<12	3.2	3.9
12-30	3.5	4.3
32-60	4.1	5.0

Pump station suction pipes and wet well geometry should be designed to minimize the buildup of organic matter thus reducing the generation of dissolved sulfide and hydrogen sulfide gases. Wastewater discharged from force mains to manholes should enter at the invert or below the low water level to reduce disturbance. For larger force mains where this application may not be possible the manhole will be constructed to accept the flow from the force main and direct it into the mainstream flow channel by way of a smooth transition. In general, pump stations should be designed with the following guidelines:

- Use variable speed pumps for decreased detention time by adjusting the pump level switches.
- Influent drop pipes should be used to bring wastewater in below the wet well water level to reduce turbulence, a stilling well is also acceptable.
- Pump suction should be of a great enough velocity to move solids and eliminate dead spots at base elevation.
- Force main tie in location and detail per Standard Detail No. 411

During the initial years of pump station operations, when flows are lower than future expectations, it is recommended pump RPM's be increased to move wastewater through the main(s) at higher velocities and therefore reduce detention times.

Hydrogen sulfide is a colorless gas with a foul odor, it is slightly heavier than air and is toxic to humans at higher concentrations. Hydrogen sulfide can be problematic to the City's owned and operated sanitary sewer systems in that it has the potential to produce nuisance odor and can be a destructive corrosive compound in the form of sulfuric acid. The conditions required for hydrogen sulfide corrosion are as follows:

1. Presence of dissolved sulfides in the water.
2. Release of hydrogen sulfide gas from water phase to gaseous phase
3. Biological oxidation of hydrogen sulfide to sulfuric acid above the wastewater surface in a pipe or basin.
4. Acid attack on the moistened surfaces of cementatious or metallic surfaces exposed to the atmosphere

Further, sulfides and their presence in sewer systems is usually due to the bacteriological reduction of sulfate in the absence of oxygen and the presence of organic matter.

The main strategy in designing sewer systems is controlling and preventing the generation and formation of hydrogen sulfide. This mainly involves several design features such as but not limited to choices of sewer and force main pipe material, sewer routings, sewer slopes, sewer pipe sizes, sewer flow type (gravity and/or pumping), flow retention time, sewer flow characteristics such as dissolved oxygen, flow pH value, flow temperature, sulfur compounds and other design features.

The gravity sewer collection system has the following characteristics:

- The sewers are built on an alluvial fan having an average slope of approximately 3%.
- Detention times throughout the system are minimal (less than one hour)
- Gravity sewers are built with PVC pipe
- Manholes are coated at points where greater turbulence is suspected
- Manholes are designed with drops of at least 0.2 feet through the manhole

This results in limited susceptibility to hydrogen sulfide problems. The aggressive slope of the sewers, the limited detention times, and the possibility of reaeration, limits the chance of the sewage becoming anaerobic in nature.

Another approach to hydrogen sulfide related issues is the use of predictive calculations or forecasting where hydrogen sulfide will occur. An example of predictive equations, were those in the 1970's by R.D. Pomeroy and supported by the EPA in 1985.

3.0DESIGN BASIS

Engineering / Design is based on the Standard Details, Specifications and Design Criteria

Modifications to the basic design criteria will be performed only upon written agreement between the Lake Havasu City. Omissions or other modifications to the design criteria will be identified to the client and the design will be altered only upon agreement by and direction from the Lake Havasu City, City Engineer or designee.

Design reviews will be performed at appropriate stages in the design. All design review comments will be resolved prior to final approval.