



City of Phoenix
WATER SERVICES DEPARTMENT

WASTEWATER LIFT STATION DESIGN GUIDANCE MANUAL

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HIGHLIGHTS AND REVISIONS

Page Number	Revision Number	Date	Description of Change
All	1.0		Complete Revision and Update
22	2.0	11/1/12	Revised the distance between the forcemain discharge and the highest influent sewer in a manhole to match Water Service Department Detail S-511, Wastewater Manhole Forcemain Tap
All	3.0	11/1/12	Revised organizational designations to match current City structure

SECTION 1 - PURPOSE AND USE OF GUIDE

1.1 Purpose

The purpose and intent of this Wastewater Lift Station Design Guidance Manual (hereafter referred to as “Design Guide”) is to provide City personnel and consultants for both Capital Improvement Program (CIP) and Private Development projects with a manual describing equipment standards and general design parameters for the design of wastewater lift stations **that will ultimately be owned and operated by the City of Phoenix**. It is recommended that privately-owned lift stations also follow the requirements of this manual because they will need to be upgraded should the City ever be asked or required to assume responsibility for them. This manual provides a framework that the consultant will build upon to satisfy both the City’s and the client’s requirements. It is to be used in connection with, not in lieu of, the Water Services Department’s Guide Specifications.

The design criteria presented in this manual are intended to serve as a guide to the design of wastewater lift stations and supplement the design information provided in the City of Phoenix Design Standards Manual for Water and Wastewater Systems. This Design Guide is neither a master document on wastewater lift station design, nor is it meant to provide a cookbook approach to design. Project design criteria may be subject to modifications to meet project specific requirements, satisfy code revisions, or address adjusting client requirements and standards.

1.2 Use of the Design Guide

It is the role of the design consultant to use this manual while working in tandem with the Water Services Department (WSD) staff to arrive at the proper engineering solution for the situation. Any deviation from the design criteria presented in this manual shall be identified by the design consultant and presented to the City for approval during the design effort. Signature by the Deputy Water Services Director, Wastewater Engineering Design and Construction Management, or his/her designee, of the final plans for the project shall be proof of the City’s acceptance of any substitutions agreed to during design. The lift station designer will be responsible for the appropriate use of these guidelines, figures, tables, etc., and will be expected to prepare and seal all necessary design calculations, reports, drawings, and specifications for each site.

SECTION 2 - PROJECT PROCEDURE

2.1 Design Milestones

All construction drawings for new wastewater lift stations are subject to reviews by two City departments. The City Water Services Department (WSD) conducts a review seeking compliance with manual standards (Federal, State, County, and City, Process and Operation, and APP requirements), while the Planning and Development Department (P&D) evaluates plans according to site development and building code requirements. The WSD review process for City owned and operated lift stations is detailed below. For more information on the site development and building review process, please contact P&D at (602) 262-7811.

The WSD conducts four stages of review for all City-owned and operated wastewater lift stations for both developer-funded and CIP funded projects. The intent of the WSD staged review process is to allow the City to provide its expectations to design engineers throughout the design process. The four levels of review conducted by the City are the 30% conceptual, 60% preliminary, 90% pre-final, and 100% final design. The design consultant shall conduct a meeting at each of the stages to review and discuss the City's comments.

In addition to staged design review meetings, the WSD may require additional workshops to discuss detailed design of specific elements (process control strategies and equipment, security, etc.) of the project. The design consultant should discuss these items with the WSD as soon as practical in order to determine the number and extent of these workshops.

All submittals for private developer funded lift stations must be delivered to the Infrastructure Record Services counter on the 8th floor of Phoenix City Hall and accompanied by a Water Services Department Plan Submittal Form and the appropriate plan review fee.

All submittals for WSD CIP projects must be delivered to the appropriate project manager on the 8th Floor of Phoenix City Hall.

2.1.1 30% Conceptual Design

A Conceptual Design Report (CDR) shall be submitted to the WSD for approval. The report shall include the project's background information such as location (quarter section, major cross streets, etc.), service area, zoning and land use, population, water demand data, and basis of design. The basis of design shall include, at a minimum, a conceptual site layout, force main alignment, design calculations, preliminary control descriptions, preliminary equipment sizing, phasing, and identification of all required easements, licenses, rights-of-way, etc. In addition, the report shall provide an anticipated list of drawings (by discipline) and City of Phoenix standard specifications sections that will be developed for the project. All assumptions shall be clearly identified and listed.

The CDR must use an area-wide approach that includes the areas within the gravity drainage basin that could be served in the future by the lift station. If an approved master plan for the service area exists, the CDR will document how the station will comply with the recommendations of the master plan. If one does not exist, a master plan for the potential service area must be completed and approved at this stage. See Section 4 for guidance on flow analysis.

Once completed, the CDR must be signed and sealed by a registered professional engineer in the State of Arizona and submitted with six (6) copies to the WSD for review and approval prior to progressing to the 60% Design Stage.

2.1.2 60% Preliminary Design

The Preliminary Design Report (PDR), plans, and specifications are submitted to the WSD for review after the conceptual design report is approved. Comments from the CDR review must be incorporated into the PDR. At a minimum, the report shall contain the following:

- Design parameters calculated in the hydraulic analysis
- Preliminary pump flow rates
- Preliminary system curve
- Preliminary manufacturer's pump curves for initial and future flows
- Minimum and maximum flow velocities through the system piping
- Maximum allowable pump shutoff head
- Frictional head loss calculations
- Surge analysis report
- Hydraulic grade line
- Pipe class rating
- Other pertinent engineering data developed for the design

The plans should represent approximately a 60% percent completion level of detail in all disciplines. At a minimum, these plans shall include the following:

- Preliminary site plans
- Preliminary landscaping plans
- Preliminary civil and electrical site plans
- Preliminary civil, structural, mechanical, and electrical details
- Preliminary grading and drainage plan
- Preliminary force main plan and alignment
- Completed wet well plan and sections
- Odor control layout and preliminary details
- Preliminary single line diagram
- Preliminary control schematics
- Completed P&IDs
- Preliminary terminal strip drawings

The specifications should be redlined edits of the Water Services Department Standard Guide Specifications.

The PDR, Preliminary Design plans, and specifications must be marked as to their stage of development and six (6) copies submitted to WSD for review.

2.1.3 90% Pre-Final Design

Once the 60% preliminary plans, specifications, and PDR are approved by WSD, the Final Design Report (FDR) and 90% pre-final plans and specifications can be completed. Comments from the PDR review must be incorporated into the Final Design Report (FDR). The plans shall be complete including all required site, civil, process/mechanical, electrical, instrumentation and control, architectural, structural, and landscaping plans and details.

Any proposed deviations to material items (manufacturers, testing requirements, etc.) within the standard specifications shall be specifically noted and presented to the City for approval at this stage. All Notes to Specifier flags shall be addressed and replaced by appropriate responses.

The Final Design Report must be signed and sealed by a registered engineer in the State of Arizona, and six (6) copies submitted to WSD at the time of 90% pre-final plan submittal.

Key design criteria from the Final Design Report should be included on the General Notes sheet of the Final plan set. These criteria include wet well dimensions and volume, pump capacity and horsepower, dual force main length and diameter, odor control type and capacity, generator size, etc. This information must be provided for all phases shown on the drawings. The content of this General Note sheet, as well as the entire plan set, must be discussed at length with the WSD and is subject to its review and approval.

2.1.4 100% Final Design

100% plans and specifications can be completed and submitted for signature once all previous review comments have been resolved. These plans and specifications must be signed and sealed by a registered engineer in the State of Arizona and six (6) copies submitted to WSD. In addition, submit one (1) electronic copy of the plans, specifications, and FDR in .pdf format. Once the plans are signed by the WSD, the P&D building permit review process can begin. The design consultant is responsible for notifying WSD of any P&D proposed changes prior to implementation.

Maricopa County Environmental Services Department will issue the Approval to Construct for all CIP projects. P&D will issue the Approval to Construct – Construction Authorization for private developer funded projects upon approval of 100% plans and specifications. However, construction cannot begin until all applicable building permits have been obtained through P&D.

2.2 Project Phasing

Project phasing must be established at the conceptual design level. The lift station design must take into account initial flow volumes as well as build-out flows and attempt to

optimize performance for both. Major elements such as the wet well, electrical service, panels, odor control, etc. shall be sized for the ultimate condition, but serious thought needs to be given as to the expandability of **all** site components in order to allow the capacity of the station to grow as the demand grows. For example, pumps rated at 1800 gpm to service build-out flows will not provide acceptable operating conditions when initial flow demand only requires 120 gpm.

The design consultant shall provide a detailed discussion of any proposed phasing and the recommended design approach in the CDR. Design of the project will not move forward until the WSD approves the phasing approach.

2.3 CADD Standards

All plans prepared for WSD sites, including those that are privately funded, must comply with the most current version of the City of Phoenix Water Services Department CADD Standards Implementation Plan (CADD Plan). This document consists of three sections: Project CADD Plan, Standard CADD Practice, and Project-Specific AutoCAD Files.

The purpose of the CADD Plan is to ensure consistent documentation, quality, and file structure for all drawings produced. It organizes the drawings, including the submittal dates, and is tailored to include information specific to the project. Compliance with the Project CADD Plan will expedite the electronic transfer of data and minimize drafting effort. The WSD will provide a copy of the basic CADD plan to the designer who will customize the plan for the specific project. The customized plan will be submitted to WSD for review and approval prior to submittal of 60% Preliminary drawings. The City or a consultant hired by the City will examine plans at the 60% and 90% design stage to confirm compliance with the CADD Plan.

2.4 Water Services Standard Guide Specifications

The Standard Guide Specifications contain specific equipment requirements and technical information not found in this manual. The Standard Guide Specifications must be obtained from WSD for use on all projects pertaining to City-owned facilities. These specifications serve as a guide for the design engineer and must be modified as appropriate for each project (see Section 2.1.1).

SECTION 3 - AGENCIES, CODES, AND PERMITS

3.1 Agencies and Publications

The design of wastewater lift stations in the City of Phoenix shall comply with all relevant industry codes and standards, a list of which is included in the WSD Standard Specifications. The current version of these documents effective at the time of receipt of notice to proceed with design shall be used as reference for design purposes. In case of conflict between the requirements of this document and any code duly adopted by the local permitting agencies, the code requirements shall prevail.

In addition to the codes and standards referenced above, the following documents or agencies shall be consulted or referenced during design as necessary.

- ADEQ Arizona Administrative Code, Title 18: Environmental Quality, Chapter 9: Department of Environmental Quality Water Pollution Control
- Arizona Game and Fish Department
- Maricopa County Health Code
- Flood Control District of Maricopa County (FCDMC)
- City of Phoenix Design Standards Manual for Water and Wastewater Systems
- City of Phoenix Zoning Ordinance
- City of Phoenix Planning and Development Department (P&D) and Street Transportation Department (STD) for floodplain management
- U.S. Army Corps of Engineers (Corps)
- U.S. Department of Housing and Urban Development
- Local zoning, ordinances, codes, development, setback and fencing, landscaping, and noise control requirements
- Local utility companies

3.1.1 Planning and Development Department

In general, the major permitting agency reviewing the project will be the City Planning and Development Department (P&D). The WSD Distribution and Collection Engineering Division, with assistance from WSD Wastewater Collection staff, is responsible for approving the design, whereas the Site Development and Building Safety Sections of P&D are responsible for performing ordinance and code compliance reviews and issuing construction permits and use permits. P&D maintains a process overview of their submittal process, including Pre-application meeting requirements, gate control access requirements, tables and checklists depicting zoning ordinances/summaries, etc. of permitted uses developed by P&D. These ordinances/summaries and checklists are provided as a point of beginning in the permit process to ensure that at least the minimum project information is included in the review set.

For WSD CIP projects at existing sites, the permitting agency will be the Annual Facilities Program (AFP) office. AFP falls under P&D and is designed to provide streamlined permit reviews for existing facilities. The permits acquired through AFP include a Building Permit, which includes Structural/Architectural, Plumbing,

Mechanical, and Electrical, and a Fire Protection Permit. To obtain information on the AFP process, call (602) 262-7501.

The Planning and Zoning Section of P&D administers the Phoenix Zoning Ordinance and regulates planning and zoning requirements through the Site Development and Building Safety sections. Wastewater lift station site plans must adhere to the design review guidelines and zoning district standards that are outlined in the current Phoenix Zoning Ordinance. The design review guidelines apply to all projects located within the City, while zoning district standards such as wall height and landscaping setback requirements may vary by zoning district.

Once a site plan has been developed, the design consultant should meet with staff at the Site Development counter (Counter 6) on the second floor of the Development Center. Staff will provide an initial review and determine if the scope of works warrants a site plan review and how any site plan should be processed. It may be possible to log site plans in for review and approval without a pre-application meeting. If not, staff will instruct the consultant on how to prepare a pre-application context plan submittal.

Information on the development process, including current fees and review timelines, is available at <http://phoenix.gov/DEVPRO/index.html> or call (602) 262-7811.

3.1.2 Fire Department

Fire Department site plan reviews are conducted when plans are submitted to P&D. Refer to the applicable Phoenix fire code for complete requirements regarding fire department site access, water supply, and on-site chemical storage plans. The design consultant shall discuss these code requirements with the City and incorporate any applicable City modifications. To obtain general information on the City of Phoenix Fire Department process and procedures call (602) 262-6002 or visit the Fire Department's website at www.phoenix.gov/fire. WSD will facilitate a meeting with a Fire Department representative to obtain details regarding all applicable design standards upon request.

3.2 Permits and Regulations

3.2.1 Building Permits

The current City of Phoenix Building Code shall govern design and construction of buildings, structures, and equipment. The design consultant shall attend meetings with the appropriate agencies, along with the City's Project/Program Manager, to initiate informal discussions and determine special permitting requirements that need to be incorporated into the design. The design consultant will be responsible for completing the permit application and notification packages and for submitting them to the City for final review and to various agencies for final processing. The efforts of the design consultant will include providing all technical assistance and background studies necessary to meet the requirements of the permitting agencies. The design consultant shall assist the City in follow-up actions with the permitting agencies and shall provide responses to questions directed to the City. All discussions and correspondence with the various agencies shall be coordinated through the WSD.

Original design permits will be kept by the WSD with copies retained by the design consultant. The design consultant shall be responsible for incorporating all requirements of the various permits and approvals into the design/construction documents.

3.2.2 Real Estate Acquisitions

All real estate acquisition/easements, etc. must be complete and recorded with the County before the project can be bid. For a CIP project, the acquisition of property rights will be obtained through the City's Real Estate Division. It is the design consultant's responsibility to prepare boundary surveys, site maps, and legal descriptions of the survey, and to assist the Real Estate Division as required/requested. The Real Estate Division will perform the required title search, direct the environmental assessment, appraise the property, negotiate with the property owner, and finally acquire the property or easement.

The acquisition of property rights for lift stations and all associated piping constructed by private developers, including rights-of-way and/or permanent and temporary easements, shall be obtained by the developer at the developer's sole cost and expense. It shall be the developer's responsibility to prepare the required documents, in form and content acceptable to the City of Phoenix, to acquire the subject property rights on behalf of the City of Phoenix. Deeds and conveyance documents shall be prepared and submitted to WSD prior to completion of final construction documents. Upon final acceptance of construction, the City shall record the deed(s) with Maricopa County subject to Phoenix City Council approval. Document numbers for all acquired property rights shall be provided on the final record drawings.

3.2.3 Environmental Permits

Environmental issues can vary widely within a given project. Therefore, during project planning and implementation, careful consideration must be given to the requirements of various federal and state environmental laws and regulations.

3.2.3.1 Water Quality

If Waters of the United States (in the desert, this includes ephemeral washes) are impacted by a proposed project, a Clean Water Act Section 404 permit will be required from the U.S. Army Corps of Engineers (Corps). A Nationwide permit refers to a general permit that authorizes a specific activity. Depending on the proposed activity and acres of impact, a preliminary jurisdictional delineation is typically performed by the applicant and submitted to the Corps for concurrence. If more than 0.5 acres (current as of this manual update) per jurisdictional wash of permanent impact will occur, an Individual permit will be required. The application process for an Individual permit is much more time consuming in comparison to the Nationwide permit application process. If jurisdictional waters are avoided, a Section 404 Permit will not be required. Contact the WSD with questions regarding any of the 404 permit requirements.

A Section 401 State Water Quality Certification Permit from the Arizona Department of Environmental Quality will be necessary prior to the 404 Permit. The Nationwide permits have conditional certifications already in place, which are effective except for on tribal lands. Individual Section 404 permits will need an individual 401 water quality certification. The Arizona Department of Environmental Quality (ADEQ) has established a general AZPDES permit for storm water discharges from construction sites. This permit was issued on February 28, 2003 and replaces NPDES permits previously issued by the U.S. Environmental Protection Agency (EPA) in 1998. The permit number is AZC2003-001. Coverage under the permit is required for all operators of construction sites that disturb one or more acres (current as of this manual update) of soil through grading, trenching, or excavation. ADEQ should be contacted at (602) 771-4428 for further information.

3.2.3.2 Biological Evaluation

The U.S. Fish and Wildlife Service and the Arizona Game and Fish Department must be contacted for a list of federally protected plant and animal species that have been documented within the vicinity of the project area. A biological evaluation will address the potential for special status species to occur within the project area.

The Arizona Department of Agriculture must be given a Notice of Intent to Clear Land of protected native plants per A.R.S. 3-904 and 3-905. This notification regarding the intended destruction and/or salvage of native plants must be given at least 20 to 60 days before plants are removed, depending on the size of the project area and the ownership of the project, i.e. private property or municipally-owned property.

3.2.3.3 Air Quality

Air quality permits and dust control permits are required from the Maricopa County Air Quality Department (MCAQD). In the event that one or both of these permits are waived by these agencies, a waiver letter from the issuing agency (MCAQD) stating that the permits are not required must be submitted to WSD. In either case, designers will be required to meet with MCAQD for determination and required action within the permitting process.

New and rebuilt standby generators must comply with the New Source Performance Standards in Title 40 of the Code of Federal Regulations Part 60, Subpart III and the generator manufacturer's emissions certification statement must be included in the application for the air quality permit. Operations and Maintenance (O&M) Plans for the odor control system or any air pollution control device must follow the format established by the Compliance and Regulatory Affairs Office (CRAO). All applications require a review and approval by CRAO prior to submission to the MCAQD. Consultants will provide the application and processing fees associated with the development with the permit. Draft permits should be forwarded to CRAO for review and comments, and the permit negotiations should be lead by CRAO.

Commencement of construction, as defined by Maricopa County Air Pollution Control Regulations, Rule 100, will not occur until the issuance of a valid air quality permit and dust control permit. The original air quality permit and a copy of the contractor's dust control permit will be submitted to CRAO. The consultant will log the hours of operation for the standby generator, record the reason for operation of the generator and meet all other requirements listed in the air quality permit. This includes completing the compliance determination (e.g., hydrogen sulfide evaluation) according to the schedule in the air quality permit, testing of rebuilt engines, and other compliance requirements. In addition, the consultant will maintain a daily dust log, complete applicable dust training courses and meet all other requirements for compliance with Maricopa County Air Pollution Control Regulations, Rule 310. All costs associated with the initial compliance activities will be the responsibility of the consultant. WSD will assume the permit administration activities after the acceptance of the lift station.

3.2.3.4 Cultural Resources

A consideration of cultural resources that might be present in a project area must be part of the planning process. Cultural resources are defined as archaeological sites and canals, historic buildings and structures, traditional cultural places, and other places or objects that are important in our history. A project area may need to be surveyed, monitored, and/or have testing and data recovery completed by a qualified archaeologist in consultation with the City of Phoenix Archaeologist. If cultural resources are identified by the City Archaeology Office's assessment, one of the City's on-call consultants will be contacted by the City Archaeology staff to prepare a compliance/treatment plan so that potential impacts of the project can be mitigated in accordance with the applicable historic preservation laws.

Compliance requirements for a project will vary depending on the scope of the work and level of City, State, and Federal involvement. To determine which levels of compliance are required, or to get answers to any other questions one might have regarding city archaeology policy, the City of Phoenix Archaeologist should be contacted at (602) 495-0901. Guidelines for conducting archaeology in Phoenix can be viewed and down loaded from the web site www.pueblogrande.com.

For all City projects, City policies regarding preservation and treatment of cultural resources must be followed. If the State of Arizona is involved, the project must comply with the Arizona Antiquities Act (A.R.S. 41-841 through 41-847) and the State Historic Preservation Act (A.R.S. 41-861 through 41-864). The project must also consult with the appropriate State agencies involved, including the State Historic Preservation Office (SHPO). A project with federal involvement will have to comply with Section 106 of the National Historic Preservation Act (NHPA) and consult with the federal agency or agencies involved.

If previously unidentified cultural resources are encountered on a job site, work shall stop within 10 m (33 ft) of the discovery until the City Archaeologist can be contacted and allowed time to make a proper assessment. In the event that human

remains or funerary objects are encountered as part of the aforementioned discovery, then the City Archaeologist must be contacted so that the appropriate Native American Tribe(s) and the Arizona State Museum ((520) 621-4795) can be contacted in order to determine the proper disposition of those remains. This includes federal, state and private lands, as per Arizona law (A.R.S. 41-844 and A.R.S. 41-865) and the Archaeological Resources Protection Act of 1979 (ARPA) and the Native American Graves Protection and Repatriation Act of 1990 (NAGPRA).

3.2.4 Construction Permits

An Approval to Construct permit must be obtained from the Maricopa County Environmental Services Department (MCESD) (or WSD County Health Delegate) prior to commencement of construction. In general, if the City is not contributing funding to the project, WSD will provide the Approval to Construct. The engineer must obtain an Approval of Construction prior to receiving final acceptance from WSD. The application packets for both of these permits are located on the MCESD website. If the WSD County Health Delegate is approving the permits, WSD will provide the appropriate application forms. These permits are required for both City and developer-built projects. Copies of both permits shall be submitted to WSD upon receipt.

In addition to the Approval to Construct, P&D requires building and civil permits for various systems, structures, or modifications to the building site. Most of these permits are necessary in order to begin construction. Depending on the scope of the work and the contractor's means and methods, other permits such as clearing and grading, traffic control, hazardous materials storage, etc. may be required. Since each project is unique, the design engineer is encouraged to contact P&D early in the review process for a listing of permits and associated fees that are anticipated for the project.

For a developer-built project, WSD requires an additional permit for third-party observation of the construction. The fee for this permit is based on the engineer's estimate of construction costs and is due upon completion of design.

3.3 Utility Coordination

In general, utility coordination for developer-built lift stations and force mains will be the responsibility of the developer. P&D will require the developer to provide utility conflict notices and resolutions. The developer is required to establish all necessary utility accounts and shall provide a list of the accounts to WSD at the start of construction. Prior to final acceptance, the developer shall provide documentation that all subject accounts have been transferred to the City.

For CIP projects, design consultants are responsible for: (1) coordinating the design with affected utilities, (2) performing utility conflict reviews, (3) establishing and/or verifying availability and service requirements. Design consultants shall coordinate with utility companies through WSD and the Street Transportation Department's Utility Coordination Section (Streets Utilities). All discrepancies found between the utility as-built drawings and field information should be discussed with the applicable utility

company. All communication concerning utility conflicts shall be made through Streets Utilities.

3.4 City Review and Permitting Fees

Both WSD and P&D charge fees for all private development projects submitted for review. P&D also charges certain fees for every permit for which an application is submitted. WSD fees are assessed at each stage of review, while P&D fees are assessed on grading and drainage, site plan, landscaping, fire, building plan, and various other applicable project reviews. The P&D also charges permitting fees for an assortment of civil and building permits, as well as other project-specific permits that may be required.

A listing of P&D's current fees can be found at www.phoenix.gov. To get WSD's plan review fees, call (602) 534-5813. All fees are subject to change at any time.

SECTION 4 - FLOW ANALYSIS

Design and sizing of wastewater lift stations must consider flows expected at startup, the flows expected at ultimate build-out (if applicable), as well as the flows expected during the years between startup and build-out. Initial and ultimate contributory flow areas to the facility must be identified., Once the contributory area is established, the land use and zoning for that area need to be considered. Different land uses generate different flows.

If an approved Master Plan exists for the service area, it must be incorporated into the analysis of design flows. The Master Plan should be re-evaluated for current conditions to ensure that changes in zoning, design parameters, future land use, etc. are addressed properly. If a Master Plan does not exist, one will need to be created (Section 2.1.1).

4.1 Flow Generation

To determine the design flows consult the latest edition of the *City of Phoenix Design Standards Manual for Water and Wastewater Systems* and the Arizona Administrative Code. This manual lists acceptable flow rates based on various land uses.

Once the contributory land uses are established, the zoning determined, and any large facilities identified, an estimation of the number of residences, and the total area of commercially/industrially zoned land use can be used to determine the total average daily flow expected to be generated by the contributory area. This flow rate is expressed in gallons per day (gpd). However, if the area under consideration will be developed in phases, the flows for each phase will also need to be determined. This may mean the lift station will need to be constructed in phases, or at least designed to allow for future expansion, (see Section 5, Hydraulics).

4.2 Peaking Factors

The peaking factor is used to determine the dry weather design flows to size the collection system and pumping facility. It does not take into account wet weather flows, or those flows caused by inflow and infiltration (I&I) during storm events. Design wet weather flows are addressed by the Arizona Administrative Code. The code (R18-9-C305.D.1.b.) states that sewers (and by extension lift stations) shall have sufficient capacity to convey peak wet weather flows produced by a 10-year, 24-hour storm event without causing any overflows.

The City of Phoenix applies peaking factors based on average daily sewage flow. For new designs, the engineer will use the peaking factor that was used for sizing the connecting upstream sewers per *The City of Phoenix Design Standards Manual for Water and Wastewater Systems*. For existing sites with average daily flows less than or equal to 2.0 MGD, a peaking factor of 4.0 is applied, while for average daily flows greater than 2.0 MGD, a peaking factor of 2.5 is applied. To determine the maximum dry (peak) daily flow, the peaking factor is multiplied by the average daily flow. For example, if the average dry daily flow for an area is determined to be 10,000 gpd, the daily peak dry flow is considered to be 40,000 gpd.

4.3 Design Flows

There are several flow rates required to size the pumping system, with the average daily flow being the basis. The daily maximum flow (peak hour flow) is determined as explained above (Section 4.2), by multiplying the average daily flow by a peaking factor. Peaking factors vary throughout the literature, with many municipalities applying peaking factors based on their own flow records. Prior to design, WSD, as well as the most current edition of the Arizona Administrative Code, Title 18: Environmental Quality, Chapter 9: Department of Environmental Quality Water Pollution Control should be consulted to verify the peaking factors. The flow rates determined in this section will be used to size the lift station in Section 5.

The following outline can be used as a guide to determine the contributory flows and assist in obtaining City approval to construct a wastewater lift station.

- Determine area of contributory flow:
 - Present
 - Future Development Expansion (if applicable)
 - External Flow Contributors
- Master Wastewater Development Plan:
 - Review and re-evaluate existing Master Plan(s)
 - If one does not exist, a Master Wastewater Development Plan must be developed by a design consultant and approved by the WSD.
- Land Use map:
 - Zoning
 - Current
 - Future
 - Show/Discuss existing/proposed:
 - Large Commercial Developments
 - Large Industrial Developments
 - Requirements
 - Related Populations
 - Current
 - Future
- Table of flows:
 - Residential (per capita)
 - Commercial (per acre or facility)
 - Industrial (per acre or facility)
- Calculate flows per area
- Include the above exhibits and calculations in the conceptual design report required by Section 2.1.1
- If the area/facility will be phased, the above information will be required for each phase

SECTION 5 - HYDRAULICS

A hydraulic analysis shall be performed on all new wastewater lift stations and any wastewater lift stations that are being upgraded or otherwise modified. The analysis is used to determine the type and size of equipment necessary for efficient pump operation and to alleviate hydraulic surges during normal operation and during electrical power failures. The City recommends the latest edition of “**Pumping Station Design**”, edited by Garr Jones and Robert Sanks as a reference for lift station design.

In the following paragraphs, the terms *firm*, *design*, and *emergency* will be used in reference to lift station capacity. For the purpose of this manual, the *firm* capacity is defined as the capacity of the lift station with the largest pump out of service. The *design* capacity is the capacity required to meet the peak daily flow of the wastewater from the service area served by the station. The *firm* and *design* capacities are often the same, but can vary when more than two pumps are installed. Finally, the *emergency* capacity is defined as the capacity of the lift station with all pumps running (at full speed for VFD situations). WSD prefers constant speed pumps for lift stations with capacities less than 5 MGD. Lift stations using variable speed pumps may be considered for higher flows. The focus of this section is on stations with constant speed pumps.

5.1 Wet Well

As stated in Section 2 and Section 4, several flow conditions must be considered when sizing the wet well. The wet well must be sized to provide efficient operation at the ultimate build-out capacity, but must also be able to function with startup flows and during all planned phases of expansion. The storage volume required in the wet well depends on the method of pump operation, i.e. constant or variable speed, but in all cases shall limit the detention time of wastewater under average flow conditions to no more than 30 minutes. This means that, at a minimum, the pumps will have 2 cycles per hour. The pumps can cycle on more often in order to reduce the required wet well size, but the number of pump cycles in an hour shall not exceed 6. The computed volume of the wet well shall not include any capacity from upstream gravity sewer lines or manholes.

The minimum operating volume of the wet well, defined as the volume between the pump start and pump stop levels, can be determined using the following equation:

$$V = \frac{tq}{4}$$

Where

V = required volume between start and stop elevations for a single pump, (or a single speed step increase for adjustable or variable speed operation), gal
 t = minimum time of one pumping cycle - time between successive pump starts, (or time required for a speed or capacity change), min
 q = pumping capacity, or increment in capacity where one or more pumps are operating and an additional pump is started, (or where pump speed is increased), gpm

The “pump off” level must be high enough to keep the pumps submerged per manufacturer’s recommendations. The “pump on” level must be set no higher than 1 foot below the invert of the lowest influent pipe.

5.2 Pumping System

For the purpose of the hydraulic analysis, the pumping system consists of the pumps, force mains, and all associated valves and fittings.

5.2.1 Pumps

Pumps must be selected that provide at least 75% efficiency at the anticipated average flow during all phases of expansion. Pumps shall be configured to operate in parallel unless otherwise approved by WSD. The minimum configuration will be two pumps, each capable of handling the peak wet weather flow by itself. When more than two pumps are specified, the system must handle the peak wet weather flow with the largest capacity pump out of service. As stated above, this is defined as the station’s *firm* capacity.

The engineer must give serious consideration to and provide strategies for handling varying flows from initial startup to ultimate build-out. At each phase, the pumps must be sized to operate efficiently at average flows while providing enough capacity to handle anticipated wet weather peak flows. To account for wear on the impeller and volute from sand, grit, and other materials in the wastewater, the peak capacity of the pumps shall be increased by 5% (i.e. $\text{pump capacity} = \text{Average Daily Flow} \times \text{Peaking Factor} \times 1.05$) unless otherwise approved by WSD.

5.2.2 Force Main

The force main(s) must be sized to achieve a velocity between 3 and 7 fps for all planned phases of expansion. Either the Darcy-Weisbach or the Hazen-Williams equations can be used to determine the head loss versus length of pipe over a range of flow rates. Both friction and minor losses must be considered during the analysis.

The engineer must provide an analysis for water hammer during design, especially if any of the following conditions exist.

- High points or “knees” in the force main
- Total dynamic head in the system is greater than 50 feet
- System velocities exceed 4 fps
- The force main is greater than 8-inches in diameter and longer than 1,000 feet

The change in pressure due to water hammer must be added to the normal operating pressure of the pipe. If the sum exceeds the rated working pressure of the pipe, steps must be taken to minimize the rate of change of velocity to limit the pressure changes within allowable ranges. An analysis of water hammer includes calculating the critical time, determining the maximum pressure increase, and selecting a method of control. Hand calculations usually suffice for simple systems, but large or complex systems may

require computer modeling in order to fully understand and design for the effects of water hammer.

The engineer shall make every effort to reduce the risk of water hammer by eliminating high points or “knees” in the force main and by providing backup power configured in such a way as to eliminate the effects of a power failure. If these conditions cannot be eliminated, the engineer shall provide recommendations for surge control based on the above analysis. Standard control measures include check valves, air/vacuum relief valves, automatic control valves, and surge relief valves and bypass piping.

5.2.3 System Head Curve

The design engineer shall develop a family of system head curves to indicate the operating envelope of the pumps throughout the life of the facility. These curves will be constructed by using varying “C” or friction factors and wet well levels. At a minimum, curves will be established for both the “pump off” level and the “pump on” level using “C” values of 100 and 120 or equivalent friction factors. The design shall be based on a “C” value of 100. These curves must be included in the Preliminary Design Report (PDR) discussed in section 2.1.2 and approved by WSD before design can continue.

5.2.4 Pump Curves

Once the system curve is developed, various pumps can be analyzed to determine which pump curves best fit the system curve. Most manufacturers provide pump curves with the TDH, efficiency, and power input plotted against the flow rate; this can be plotted on the system curve. Multiple pumps may be required to produce the necessary flow at the required head. This exercise must be performed for new designs as well as modifications to existing lift stations.

When a pump has been selected, the motor rating (horsepower) and impeller size can be established, which corresponds to the required electrical load for the pumps. Pump curves for the *firm, design, and emergency* capacities plotted with the system head curves and calculations for each pump must be submitted to the City for review in the PDR. These curves and calculations should be done for each phase of the project as defined in the Conceptual Design Report (CDR).

In the case where Variable Frequency Drives (VFDs) are used, the engineer shall prepare reduced speed curves. Curves shall be provided for the following percentages of full speed: 100, 90, 80, 70, and 60. The minimum flow rate at which the pump is capable of continuously pumping wastewater should also be identified.

5.3 Summary

The following information is required as a minimum to perform the hydraulic analysis:

- Influent Flow Rates (from Section 4)
 - Minimum Daily
 - Maximum Daily (including factor for I & I)
 - Average Daily

-
-
- Force main profile
 - Maximum allowable pump shutoff head
 - Friction factors for approved force main pipe materials (see Section 6)
 - K-values or equivalent lengths for various fittings, valves, etc on the force main
 - Pipe pressure class ratings

The force main, wet well and all yard piping shall be designed for the ultimate build-out capacity of the lift station unless otherwise approved by WSD. Planned phased expansions shall be incorporated into the ultimate design where applicable.

SECTION 6 - MECHANICAL

The standard Water Services Department's lift station consists of a wet well with submersible pumps, an above-ground force main header and valve gallery, an on-site odor control system, which may include both vapor and liquid phase aspects, an electrical line-up and backup generator. This section provides further guidance on the mechanical systems within the lift station.

6.1 Wet Well

Regardless of capacity, the wet well configuration and placement and spacing of the pumps shall comply with the Hydraulic Institute guidelines to prevent turbulence and vortexing at the pump inlet. All wet wells shall be designed for submersible pumps within the wet well. A wet well/dry well layout shall not be used without approval from WSD.

The wet well shall be constructed using cast-in-place or pre-cast concrete sections and shall be finished with an approved anti-corrosion coating system. Steel or fiberglass wet wells are not permitted and a packaged lift station shall not be used without approval from the WSD.

WSD separates lift stations into two main categories. Lift Stations with design capacities less than or equal to 5 MGD and those with design capacities greater than 5 MGD. The majority of the guidance in this section of the manual refers to the first category of lift stations. Little guidance will be given on lift stations with design capacities greater than 5 MGD since they often include more complex control systems, equipment, and configurations. The guidance that is provided for larger stations will be specifically noted. In general, WSD will require the engineer to conduct several more workshops and meetings for large lift stations than are required for smaller stations.

6.1.1 Shape and Configuration

Wet wells may be rectangular or circular depending on the capacity of the station and the hydraulic conditions. The bottom of the wet well must be sloped to the pumps in order to facilitate solids removal. This configuration is often referred to as a "hopper bottom." The engineer must design the bottom to avoid the types of adverse hydraulic conditions mentioned above. In addition, the engineer must ensure that the fillets do not interfere with the operation of the level transmitters.

6.1.2 Depth

The depth of the wet well will be determined by the lowest invert of the influent sewer(s) and the required storage capacity. The "pump on" control elevation shall be no higher than 1 foot below the lowest influent pipe invert elevation. The "pump off" control elevation shall be sufficient to provide the necessary cooling to the pumps as recommended by the pump manufacturer. If any invert elevation(s) of the influent pipe(s) has a drop greater than or equal to 5 feet to the "pump off" control elevation, a drop shaft shall be provided.

6.1.3 Other Wet Well Features

The following features shall be incorporated into the wet well design unless otherwise approved by WSD:

- Provide an access hatch with safety chains above the pumps in the top of the wet well. Hatch shall be at least a two leaf design with enough area to safely and easily remove the pumps.
- An additional hatch may be required, depending on the shape of the wet well, for the ultrasonic level transmitters and/or wet well maintenance.
- Removable aluminum safety railings shall surround the perimeter of the wet well
- Guide rails shall be constructed of Type 316 stainless steel.
- The entire weight of the pumping unit shall be guided in place by the guide rail.
- The guide rail shall not support any portion of the weight of the pump.
- The guiding rail assembly and the discharge flange assembly shall have non-sparking materials of construction components.
- Provide necessary sliding guide bracket and discharge connection elbow, which, when bolted to the floor of the wet well and to the discharge line, will receive the pump discharge connection flange without need of adjustment, fasteners, clamps, or similar devices.
- No portion of the pump shall bear directly on the floor of the wet well.

6.2 Pump Systems

The use of constant speed pumps is preferred for stations with a design capacity of 5 MGD or less. Stations designed for a capacity greater than 5 MGD may utilize variable speed pumps if the hydraulic analysis shows them to be more efficient. The designer must consult the pump and/or motor manufacturer to determine the recommended number of starts per hour for their product. This information must be presented with the wet well sizing calculations.

6.2.1 Pump Selection

The design engineer shall select the most efficient pumps from approved pump manufacturers for the given head-capacity situation. The engineer shall demonstrate that the selected pumps have a Net Positive Suction Head required (NPSH_r) that is less than the system's Net Positive Suction Head available (NPSH_a) under the worst case scenario.

Pump speed can vary between 1,155 and 1,765 rpm. Pumps shall be explosion proof with watertight motor enclosures for dry well and wet well applications. Typically, pumps installed outdoors, or in dirty or corrosive environments, require totally enclosed motors. In addition, motors installed outdoors shall have temperature ratings adjusted to suit ambient operating conditions. Motor starting equipment shall be suitable for the type of motor and required voltage. Motor starters will be designed for limiting the in-rush current where shocks or disruptions to the electrical supply are likely to occur as a result of pump start-up. Where low starting in-rush current is required for constant speed pumps, such as when using engine driven generator sets, or where the motor horsepower rating exceeds 50 hp, solid state soft starters shall be used.

6.2.2 Variable Speed Pumps

The main reason for using variable speed pumps part of a wastewater lift station design is to match variable influent flow conditions as much as possible. As a rule of thumb, variable speed pumps should not be used if constant speed pumps are capable of meeting the minimum to maximum flow range without exceeding the maximum allowable number of starts per hour or if the pump curve is relatively flat.

Variable speed systems are more complicated than constant speed systems. In general, Variable frequency drives (VFDs) are more expensive, less efficient, less reliable, and require more maintenance than constant speed systems. The additional complexity also requires additional training of operations and maintenance staff. VFDs also require air conditioned enclosures.

VFDs, if possible, shall be provided by the motor manufacturer/supplier. This ensures the VFDs are properly matched for the operating ranges they will be subject to and ensures a unit responsibility for the pump motor and drive. The VFD specifications must include a complete description of the power system including any requirements for operation from standby generators.

Minimum flow conditions should also be considered in pump selection, especially where variable speed pumps are used. In general, pumps should not be operated at less than approximately 25% of design capacity. If low flow conditions require operation at less than 25% of design flow, pumps should be set for on-off control at these low flows; alternatively, smaller pumps could be used to pump low flows. These smaller pumps shall be equipped with high-pressure cutoff of when pressure exceeds 10% of Best Efficiency Point (BEP).

6.2.3 Other Pump Features

Additional features required for pumps and pumping systems are:

- All pumps shall be close-coupled, submersible, radial flow centrifugal pumps unless otherwise approved by WSD
- Submersible pump motors shall be submerged per manufacturer recommendations
- Motors (both constant and variable speed) shall not be loaded to use more than 80 percent of the rated horsepower.
- Electrical motors from ½ hp to 200 hp shall be rated at 480 Volts, 3 phase, 60 Hz.
- Electrical motors from 200 hp to 400 hp shall be rated at either 480 or 4,160 Volts, 3 phase, 60 Hz. (WSD reserves the right to modify this requirement depending on design and operational flexibility).
- If conditions warrant, electrical motors larger than 400 hp can be rated at either 480 or 4,160 Volts, 3 phase, 60 Hz. (WSD reserves the right to modify this requirement depending on design and operational flexibility).
- If smaller motors are operating in the same group as larger motors, motors as small as 100 hp may be rated to match the larger motor's voltage, i.e. 480 or 4,160 Volts, 3 phase, 60 Hz.
- The motor torque and locked rotor characteristics will be as outlined in the NEMA standards for Design B and shall be selected to be non-overloading throughout the driven pump's full speed performance curve.

6.3 Force main

Unless otherwise approved, force mains shall be DIP and lined with an approved lining that conforms to the City Standard Specifications, MAG Specifications Section 750, and the Phoenix Supplement thereto. The designer must also determine the necessity and extent of cathodic protection.

6.3.1 Off-site

As stated in 5.2.2., all effort should be made to ensure force mains are designed and constructed to maintain a positive slope; it is not a requirement to necessarily follow the contours of the land. High points or “knees” in the force main should be avoided. If it is not possible to do so, air release valves shall be placed at high points to prevent air locking and relieve negative pressures. An odor control system, such as a passive drum air scrubber, shall be used to remove odorous air discharged from air release valves installed on force mains. Air release valves and scrubber drums shall be housed in a vault. Any liquid collected in the vault must be drained to a contained sump, which is then emptied by the WSD.

Thrust restraint shall be analyzed at each change in pipeline direction, both horizontal and vertical and shall be designed in accordance with MAG Standard Detail 303, unless approved otherwise by WSD. The severity of all direction changes should be minimized and shall be no greater than 45 degrees.

All phases of development will require a primary force main and a secondary backup force main. The backup force main provides redundancy in case the primary needs to be taken off line for servicing and/or repair. The barrel diameters may vary to account for phasing of the lift station. A minimum barrel-to-barrel clearance of 5 feet, outside to outside, shall be maintained unless specifically approved otherwise by WSD. Measures may be required to reduce the velocity before the wastewater is discharged to the gravity sewer system if the force main velocity exceeds 3 fps. These measures typically include increasing the diameter of the last 100 feet of the force mains before they discharge into the gravity sewer system. Force mains shall not discharge directly into a gravity sewer system without the use of a splitter box or a manhole. Force mains shall enter the gravity sewer system such that the invert of the force main is within 1 foot (12 inches) of the crown of the highest influent sewer. If possible, the discharge shall be oriented to discharge into the flow line of the sewer in the downstream direction in order to reduce turbulence. No valves shall be installed on the discharge end of the force main barrels.

6.3.2 On-site

The connection from each pump discharge line to the discharge manifold shall be made at approximately 45 degree angles to the centerline of the manifold. 90 degree fittings and T's shall not be used without WSD approval. If wyes are used to connect the pump discharge to the manifold the wyes shall be the same diameter as the manifold. However, depending on the site and its constraints, the use of reducing/increasing wyes or other reducing/increasing fittings may be necessary; the use of these fittings shall be reviewed on a case-by-case basis by the WSD during design. All station piping shall be supported

with reinforced concrete saddles or fabricated steel pipe supports at a height of 24 to 36 inches for ease of valve adjustments and maintenance, and shall be equipped with steel hold-down straps. All exposed piping shall utilize insulated flange gaskets as necessary to electrically isolate the station piping from the yard/system piping.

To facilitate installation and removal of valves and to accommodate slight alignment adjustments in the pump discharge piping, sleeve-type flexible steel couplings restrained by tie-rods shall be provided at each pump discharge connection. Couplings shall be located between the pump and the discharge check valve. Because these couplings are not intended to provide significant longitudinal restraint, the piping must be anchored (restrained) to prevent movement and resist thrust.

An emergency pump bypass connection assembly shall be provided on the lift station's discharge header complete with an isolation plug valve and a cam-lok fitting with cover. The discharge lines shall connect to the discharge manifold in such a way to allow a portable pump to be connected to the manifold and pump into the force main as if it were a normal station pump. An additional bypass assembly shall be installed on the redundant forcemain that allows the manifold to be bypassed. The isolation valves, check valves, and/or hydraulic/air operated plug valves located on the discharge lines shall prevent any backflow to the permanent lift station pumps.

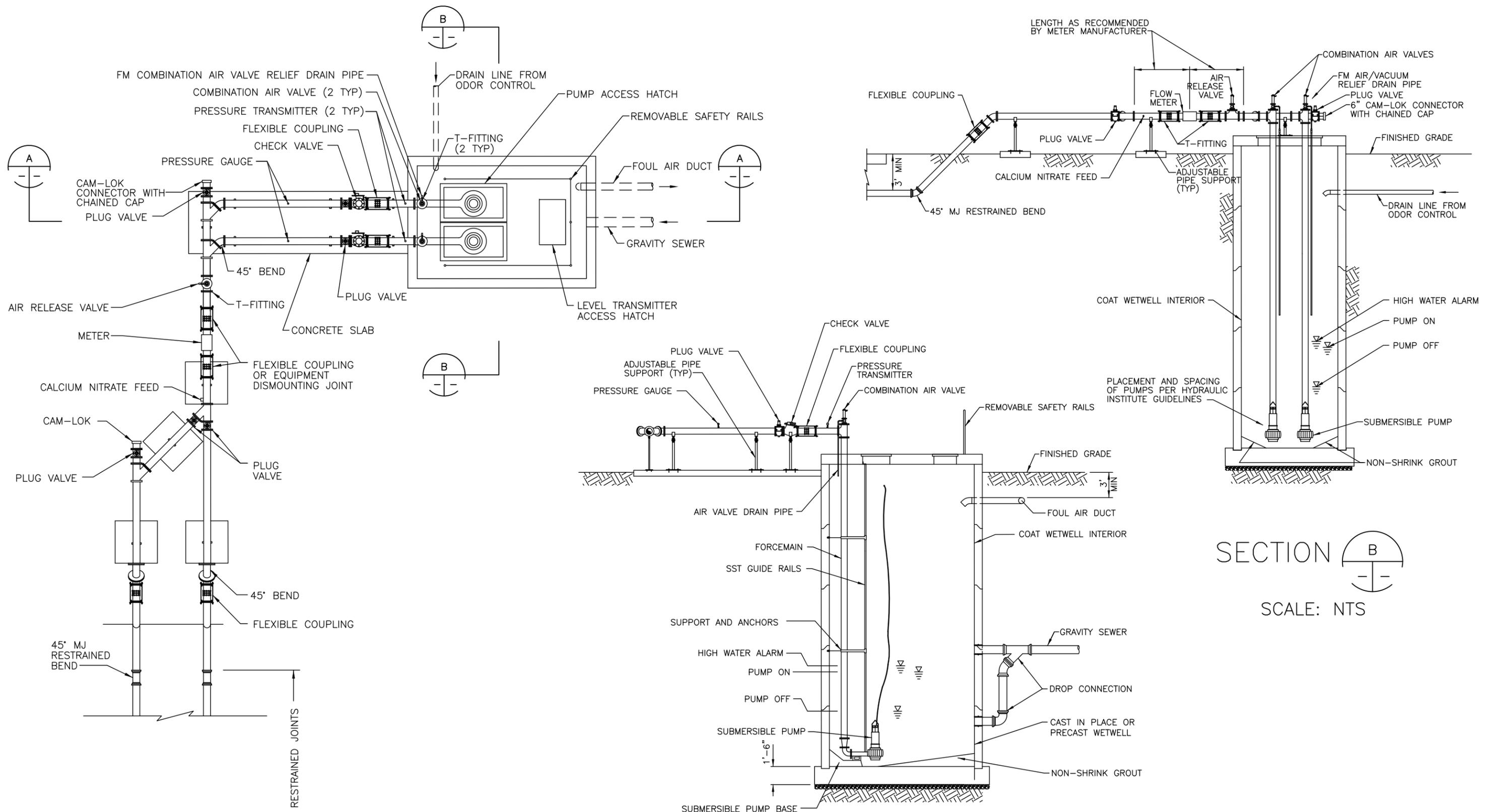
See figure 6.1 for a graphical representation of standard wet well and on-site force main features.

6.4 Valves

The configuration of valves depends on the lift station's design capacity. However, regardless of capacity, all discharge valves on the force main(s) shall be installed above grade and adjacent to the wet well. The use of a valve vault must be specifically approved by WSD.

The valves specified for use in wastewater lift stations shall be manufactured of materials appropriate for wastewater use. All valves shall be shown on the drawings. In addition, valves larger than 6 inches in diameter shall be numbered and shown on the appropriate drawing sheet(s), delineated in a valve/piping schedule, and referred to in the specifications by the valve number. This schedule shall be included in either the design drawing set or the specifications. The valve schedule shall include the valve number, location, service, valve type, class and size, quantity, actual maximum pressure and flow range, actuator service, operating time range, NEMA enclosure, and any applicable remarks such as, voltage, phase, type of connection, linings, coatings, etc.

All valves shall be rated for the range of flows and pressures produced by the system pumps and all other internal pressures developed by the system.



DETAIL 1 PUMP STATION PLAN
SCALE: NTS

SECTION A
SCALE: NTS

SECTION B
SCALE: NTS

FIGURE 6.1:
STANDARD WET WELL
AND FORCE MAIN FEATURES

Valves typically used in wastewater lift stations are divided into the following categories:

- Check/Control Valves
- Isolation Valves
- Air and Vacuum Valves
- Blowoff Valves

6.4.1 Check/Control Valves

The primary surge control valve will be an air-cushioned swing check valve. The check valve shall be installed horizontally in each pump discharge line between the pump discharge flange and the discharge manifold header.

For stations with flows greater than 5 MGD, automatic control valves may be considered. These valves can be either electrically or pneumatically controlled with electric control being preferred for larger lift stations. Normal operation of these valves upon pump shutdown is to slowly close the valve while the pump continues to run. When the valve is closed, a limit switch then stops the pump motor. Upon pump start-up these valves are closed and then are slowly opened to minimize the rate of velocity changes. On power failure, an emergency hydraulic or other type operator closes the valve slowly. The valve closure time should be based on the results of the surge analysis.

Electric valve operators shall include manual handwheel operators and shall be designed for aboveground application (if applicable). They shall be provided with limit switches for valve position indication. Valve operators shall be sized to ensure proper seating and unseating of the valve surfaces against the system and/or pumped head.

Pneumatic actuators, where approved by WSD, shall include an air compressor, compressed air storage tank, and a compressed air drier. The compressed air drier is required to remove moisture from the compressed air prior to its delivery to the actuator. This helps reduce corrosion in the airlines. The designer must ensure that the air compressor and air drier are connected to the station's standby power source. The sizing of the air compressor and air drier will be designed based on individual project requirements. Depending upon the size of the project, WSD may require a back-up air compressor and compressed air storage tank be included in the design.

The use of hydro-pneumatic tanks is prohibited without approval by WSD.

6.4.2 Isolation Valves

The main function of an isolation valve is to provide positive isolation of the pump and its valving from the piping system for maintenance purposes. Isolation (shutoff) valves are required on the discharge side of all wastewater pumps. An isolation valve shall also be provided downstream of the main discharge flow meter. All isolation valves on the forcemain shall be full-port eccentric plug valves.

6.4.3 Air and Vacuum Valves

Air release, vacuum release, or combination air vacuum/air release valves specifically designed for sewage applications shall be installed at high points at the station and throughout the length of force mains for the purpose of admitting and releasing air. Each valve shall be specified with the appropriate orifice diameter suitable for the volume of air to be admitted or released. The method to be used for sizing the appropriate air release, vacuum release, or combination air vacuum/air release valves can be found in the applicable manufacturer design guidelines. To allow periodic maintenance on each valve, an additional isolation valve (¼-turn, resilient, rubber seated ball valve) and back-flushing connection is required for each air valve. These valve assemblies, including the isolation ball valve and associated piping, shall be rated for the maximum design pressure of the system piping. All valves installed underground shall be installed in a manhole or valve structure with adequate drainage.

A combination air valve shall be installed on the vertical leg of a T-fitting on the discharge piping prior to any other valve. Additionally, an air release valve shall be installed down stream the check valves and upstream of the flow meter, again on the vertical leg of a T-fitting. The air release outlet shall be piped back to the wet well for discharge. Air release valve outlet piping shall include an air compressor type quick-release couplings.

Air release valves on force mains outside the station must have odor control and a method of disposing of the moisture released with the air. See Paragraph 6.3 for further discussion on force main design.

6.5 Flow Meters

Accurate measurement of flow discharged from a wastewater lift station is critical to the overall operation of the station. Consequently, a flow meter must be installed in the common discharge header of all wastewater lift stations to indicate and record the quantity of flow being pumped. WSD requires that this flow meter be an in-line magnetic flow meter. Restrained flexible couplings or equipment dismantling joints shall be installed adjacent to the meter to allow for easy removal and replacement. The meter must be protected from direct exposure to the sun.

For new sites, the design engineer shall provide no less than the minimum number of straight-run pipe diameters required by the flow meter manufacturer both upstream and downstream of the flow meter to ensure accurate flow measurement. Minimum velocities recommended by the meter manufacturer must be maintained through the meter at the lowest anticipated pumping rate. If this requires installation of reducers, they shall be eccentric reducers, installed flat-on-top. The piping must be configured so that the meter is always filled with wastewater.

Many existing sites have strap-on, ultrasonic flow meters. Where practical, these should be replaced. However, due to site constraints and existing piping the meter application must be designed specifically for each wastewater lift station.

As noted above, not only should meters be installed to meet the manufacturer's recommendations, but they should be configured such that alternative metering methods are available to field verify the accuracy of the installed meters. The design of the flow measurement system shall consider the type of flow meter, its final layout configuration, and required controls based on available land, the station layout, the flow meter manufacturer, and City input. Additional City flow meter requirements are listed below:

- The flow meter transmitter shall be located in an air-conditioned space if possible. A shade screen shall be constructed to shield the meter if the transmitter cannot be routed remotely.
- All discharge piping and fittings, including the metering segment, must be epoxy-lined.
- See the City's Standard Guide Specifications, Division 17052 for approved manufacturers.

6.6 Pressure Gauges

Pressure gauges and transmitters shall be installed on each pump discharge pipe prior to the check valve. The gauges will be graduated based on the anticipated pressures on the system. The transmitters will be wired to the lift station's Computer Control System and will be installed in a weather-proof housing.

6.7 Yard Piping

A potable water supply is required at all pump stations to supply yard hydrants, hose bibs and emergency shower and eyewash systems. At least three (3) yard hydrants with free standing hose racks and 50 foot, 2-inch hoses with fire nozzles shall be installed at the lift station. One shall be installed near the wet well, in a location that provides sufficient slack for work in and around the wet well but that does not hinder efforts to pull pumps or maintain valves. Another hose bib and rack shall be installed near the wet chemical scrubber, again in a location that provides convenience while allowing full access to the equipment. The final hose bib and rack assembly shall be installed near the liquid phase odor control containment area.

In addition to yard hydrants and racks, combination eye wash and emergency shower stations must be installed where appropriate. All combination eye wash and emergency shower stations shall be installed with a concrete pad and drain and anti-scald valve. Section 7 will provide more details as to the specifics.

6.8 Heating, Ventilation and Air Conditioning (HVAC)

Other than small air conditioning units on electrical panels, HVAC systems will only be required if the lift station has a building or a wet well/dry well configuration. For designs that allow direct access to the wet well, air exchange from the wet well should be both supplied and exhausted through ducts by powered blowers so a slight positive pressure is maintained. Heating, ventilation, and air conditioning equipment shall be of a safe type to provide protection of pumping equipment and accessories, as well as protection of station personnel.

Heating will only be required to prevent the freezing of equipment with automatically controlled heaters in the equipment areas. Where heaters are used, temperatures should be maintained at or above 40 degrees F.

Buildings must comply with the NFPA 2007 according to the occupancy rating, and NFPA 820. Buildings will not be constructed over wet wells. All buildings shall be well ventilated by means of windows, doors, roof ventilators, or other means approved by WSD and P&D and shall be secured against unauthorized access. All rooms, compartments, pits and other enclosures below grade for which access is provided, which may be entered and in which an unsafe atmosphere or excessive heat may develop, shall have adequate forced ventilation. The HVAC equipment shall be capable of producing at least six (6) complete room volume changes of air per hour. Rooms containing equipment or piping shall be adequately heated, vented, and if necessary, de-humidified. Where practicable, ventilation should be supplemented by insulating the building, equipment, and piping. Switches controlling forced ventilation shall be located outside such compartments.

Air conditioning shall be provided for electrical control rooms. Air conditioning will also be provided for outdoor MCCs, instrumentation, and electrical control panels. For wastewater lift stations with VFD units, two air conditioning (air handling) units shall be provided, one to act as the primary and the other as a backup. Air handling units shall be designed to prevent maximum room or panel temperatures from exceeding 75 degrees F. Where applicable, the designer shall use multiple, commercial grade, common-size air conditioning units to balance the air flow, rather than use one larger unit.

HVAC system requirements shall be defined in the Preliminary Design Report, which shall be submitted to and reviewed by WSD. HVAC systems shall be designed by a mechanical engineer, licensed to practice in the State of Arizona.

If buildings are used in the design, the main sources of station noise are anticipated to emanate from HVAC supply and exhaust systems and the use of standby emergency engine generators. Fan selection, duct sizing and configurations, and inlets and outlets shall be carefully designed to ensure that noise emissions are minimized. It is required that fans/blowers be mounted within the building to reduce noise and discharges shall be equipped with appropriate sound traps.

The ventilation and air conditioning systems shall be designed to satisfy the following codes and standards unless superseded by more stringent requirements:

- American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
- Clean Air Act of 1990 Guidelines
- National Electric Code (NEC)
- National Fire Protection Association (NFPA) 90A
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Standards
- NFPA 2007

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- Uniform Fire Code
 - Uniform Mechanical Code
 - Phoenix City Code
 - Other local codes, ordinances, and regulations

6.8.1 Equipment Layout

HVAC ductwork and systems are typically the first mechanical items installed in a building once the structure frame has been constructed. These systems must comply with the NFPA 2007. The ventilation and air conditioning systems shall be designed with adequate space for installation, operation, and maintenance accessibility and with regard for other trades. Air ducts to aboveground piping, louvers, and vents shall be adequately sized to reduce noise generation and transmission. The use of “sound traps”, duct insulation, sound baffles, etc. will be used to reduce the transmission of station noise. (See Section 13, Noise Control and Abatement, for additional requirements concerning sound attenuation). All vents and louvers open to the outside shall be screened with heavy galvanized wire mesh (maximum opening: ½-inch).

Electrical equipment associated with the ventilation system shall be UL listed and conform to the National Electric Code and City Code.

Ventilation equipment shall be controlled by a thermostat and a hand-off-auto (HOA) entry switch. Failure alarms shall be hardwired to the main station control panel and to the station’s SCADA System.

6.9 Noise Control and Abatement

Noise levels from wastewater lift stations can have a negative effect on neighbors as well as plant personnel. Neighbors are affected by transmitted noise that extends beyond project boundaries, whereas station noise can have a negative effect on the health of plant personnel. Maximum noise levels in working environments are regulated under the federal Occupational Safety and Health Administration (OSHA) and the Arizona Division of Occupational Safety and Health (ADOSH). OSHA and ADOSH requirements and regulations shall be included in the design of all structures to establish the working environment’s maximum noise levels.

Noise can come from a wide variety of sources but are mostly limited to noise generated from large equipment. These sources can include pump motors, HVAC systems, standby generator units, blowers, and fans. A significant contributor to noise can also come from operation and maintenance activities. Noise generated from these activities usually contains variations in tone or frequency. These variations typically have a greater annoyance impact on the surrounding community than simply the decibel level. Noise control measures at wastewater lift stations should focus on equipment selection, use of structure sound barriers and sound traps, acoustical shrouding and/or enclosures of equipment, wall batting, and acoustical architecture to attenuate the sound wave forms.

Construction of these facilities can also contribute significantly to noise levels resulting in human annoyance. Though construction is temporary, provisions should be included

in the design specifications to ensure that the contractor obeys all local noise ordinances. One way to mitigate construction noise may be to restrict a contractor’s work hours to specific times during the day/evening and/or require the use of temporary noise barriers.

6.9.1 Reference Standards and Codes

The following standards and codes shall be used:

- Latest updates from OSHA and ADOSH.
- The latest edition of the NFPA 2007 with City of Phoenix amendments.
- Latest update of the Phoenix Zoning Ordinance, Section 627. See Appendix A.
- Most current design requirements as established by the City of Phoenix Development Services Department (General Notes). See Appendix A. These general notes are provided to assist the design consultant in understanding elements of the City of Phoenix Development Services Department review and submittal process as well as to provide additional design criteria. These are not to be confused with the General Notes (and key design criteria information) that are required on the Final plan set (See Section 2.1.3).

6.9.2 Design Issues

City of Phoenix Planning and Development Department (P&D) and the Phoenix Zoning Ordinance have established requirements regarding noise. According to the P&D General Notes, “No noise, odor or vibration will be emitted so that it exceeds the general level of noise, odor or vibration emitted by uses outside of site.” This is interpreted by WSD as noise emitted from a wastewater lift station shall not exceed a value of 50 dB at the project property line, when measured on an "A weighted" sound level meter according to the procedures of the Environmental Protection Agency (EPA). However, if the project is located in an area with a designated zoned use of A-1 or A-2 (light industrial), according to Phoenix Zoning Ordinance, Section 627, Chapter 6, E, 3, and Section 628, Chapter 6, D, 3 “The average noise level, measured at the property line, shall not exceed 55dB (1dn) when measured on an "A weighted" sound level meter and according to the procedures of the Environmental Protection Agency.”

Table 6.1 has been provided for informational purposes only. It should be used as a frame of reference for comparing typical background noise levels for indoor and outdoor areas. This table has been reproduced in its entirety from the WEF Manual of Practice No. 8, *Design of Municipal Wastewater Treatment Plants*, Volume 1, 1991, 2nd ed.

Table 6.1 Typical Criteria for Background Noise

Space Type	Noise Level dBA
Indoor	
Conference Rooms, offices	42
Lobbies, laboratory, work areas	47 - 56
Light Maintenance shops	52 - 61

Work spaces – communication required	56 - 66
Work spaces – no communication required, but With no risk of hearing damage	66 - 80

Outdoor

Quiet residential	40 - 50
Average residential	50 - 60
Commercial	55 - 65
Industrial	60 - 70

The completed wastewater lift station designs must comply with the established P&D and Phoenix Zoning Ordinance noise requirements as discussed in the preceding paragraphs.

If buildings are used in the design, main sources of station noise are anticipated to emanate from HVAC supply and exhaust systems and the use of standby emergency engine generators. Fan selection, duct sizing and configurations, and inlets and outlets shall be carefully designed to ensure that noise emissions are minimized. It is required that fans/blowers be mounted within the building to reduce noise and discharges shall be equipped with appropriate sound traps.

The emergency engine generator shall be equipped with hospital grade exhaust silencers. If it is in a building, it shall also have inlet and outlet louver appurtenances. If the generator is located outside of the station building or within a compound, the design consultant must shroud the generator in its own soundproof enclosure. (Acoustical generator enclosures are readily available from a host of generator manufacturers). Depending on the required decibel level, multiple silencers may have to be arranged in series in order to achieve the desired decibel level. The generator may be located within a secondary containment area to lower the generator below the height of the station wall and reduce noise produced by the equipment. The containment shall not be depressed more than three (3) feet below grade and four feet of clearance between the equipment and containment walls must be provided. A six inch curb must also be provided around the containment to prevent stormwater runoff from entering. Adequate flood protection measures shall be designed into the depressed generator design to ensure protection against flood hazard. See Section 8 – Electrical for additional design criteria for standby generators.

6.9.3 Standards

The City has established these standards for the design and construction of wastewater lift stations; the designer shall ensure the station conforms to these standards unless otherwise approved by WSD. The City’s Standard Specifications and those criteria identified within this manual shall be followed. Those listed design criteria and others associated with either controlling or dampening noise levels in lift stations have been reviewed and discussed with representatives of the WSD:

- Maximum Noise Level:

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-
- According to Phoenix Zoning Ordinance, Section 627, Chapter 6, E, 3 for land zoned as A-1 and Section 628, Chapter 6, D, 3 for land zoned as A-2 use: 55 dB at the project property line.
 - According to WSD, for all land zoned other than A-1 or A-2 use: 50 dB at the project property line.
 - Select station equipment that meets OSHA levels for 8 hours of continuous exposure without requiring hearing protection.
 - Standby emergency generators shall be provided with hospital grade exhaust silencers.
 - Within station buildings and enclosures, the exhaust systems of standby emergency generators' shall be covered with high temperature insulation (inner layer shall be rated for 1,800 degrees Fahrenheit; outer layer for 1,000 degrees Fahrenheit).
 - White vinyl coated, quilted, acoustically absorptive fiberglass batting (cloth) shall be used to line the interior walls of the standby generator room and other high noise areas.
 - As an alternative to batting, slotted acoustic concrete masonry units can be substituted for standard masonry units in the construction of a building. Factory-installed, sound absorbing elements are provided in masonry unit cores. Finish and color shall be as selected by the City.
 - Sound traps on ductwork systems, generator radiator and intake louvers shall be constructed of Type 304 Stainless Steel sheets. Seams shall be locked formed. Dividers shall be fabricated of perforated 304 stainless steel sheets, cavities filled with an inert, moisture- and vermin-proof acoustical absorbent material. Basis for design shall be Industrial Acoustics Co.
 - Acoustical equipment enclosures shall be specified for individual pieces of equipment or pumps located in enclosure compounds. These enclosures shall be constructed from acoustical quilts, modular acoustical screens, or as recommended by the equipment manufacturer.

SECTION 7 - ODOR CONTROL

Odors from wastewater lift stations are typically the most significant issue for residents and/or businesses in the vicinity of the site. Therefore, all stations must have an odor control system. This system typically has two components: a component for treating foul air from the head space in the wet well and a component for preventing odors at the force main discharge and further down stream.

7.1 Downstream Odor Control

Currently, the WSD prefers to control odors downstream of lift stations by injecting a flow-paced, liquid calcium nitrate double salt solution (trade name “Bioxide”) directly into the force main (downstream of the flow meter) to reduce the formation of hydrogen sulfide. The injector and feed pumps must be capable of feeding Bioxide at the working pressures in the force main. It must also be installed in such a way as to allow easy maintenance of the injection nozzle.

The WSD prefers the use of Bioxide due to its relatively benign chemical makeup and its effectiveness. However, other methods of force main odor control may be proposed. The WSD does not permit introduction of chemicals directly into the wet well.

7.2 Wet Well Four Air

Odor control shall be provided at the wet well, and all lift stations shall use either a wet chemical scrubber or a biological system (biofilter). Alternate odor control systems may be considered by the WSD. For existing sites, odor control systems shall be designed based on sampling of the air in the sewer headspace. For new sites, the system must be designed to treat a minimum concentration of 30 ppb H₂S and upwards of 100 ppm H₂S depending on the ultimate size of the lift station. All ductwork shall be either FRP or schedule 80 CPVC and shall extend into the wet well at a minimum depth of three (3) feet below the finished grade elevation. The ductwork shall be designed to draw air uniformly from the wet well, minimizing short circuiting and stagnant areas.

Regardless of the type of odor control system employed it must be sized such that the concentration of H₂S remaining in the odor scrubber’s discharge does not exceed the Maricopa County Air Quality Rule 320. Rule 320, Section 304 states:

“No person shall emit hydrogen sulfide from any location in such a manner or amount that the concentration of such emissions into the ambient air at any occupied place beyond the premises on which the source is located exceeds 0.03 parts per million (30 parts per billion) by volume for any averaging period of 30 minutes or more.”

Individual odor control systems require an air quality permit from the Maricopa County Air Quality Department. The permit may require installation of additional equipment, such as differential pressure gauges, so it must be reviewed carefully. This permit must be in place prior to any construction taking place at the lift station. The engineer must

contact the WSD Compliance and Regulatory Affairs Office (CRAO) to coordinate acquisition of this permit.

7.2.1 Wet Chemical Scrubbers

As of the printing of this manual update, the preferred odor control technology is a wet chemical scrubber. The City standard for wet chemical scrubbers is a three stage, skid mounted unit provided by Siemens that uses sodium hydroxide (NaOH) and sodium hypochlorite (NaOCl) to oxidize the H₂S in the foul air. A fan draws odorous air continuously from the wet well through ductwork and into the scrubber. pH and Oxidation Reduction Potential (ORP) probes monitor the concentration of the chemicals and signal the feed pumps through a dedicated control panel when additional chemical is needed.

7.2.2 Biofilters

Biofilters have been introduced more recently. Currently, the WSD's standard is based on the Bohn Biofilter design. Biofilters can have a larger footprint than a wet chemical system, but provide a significant reduction in maintenance and do not require the use of chemicals. Biofilters shall be installed as close to grade level as possible while still providing a gravity drain to the sewer. The blower, blower control panel, and irrigation control panel shall all be installed above grade.

7.3 Chemical Storage

All chemicals at the lift stations must be stored and delivered by means appropriate to their hazard classification. The bulk of the following standards are also identified in the *Wastewater Collection Lift Station and Odor Control Station Assessment and Needs Report* by Black & Veatch, dated September 2007. A copy of this report is available upon request.

7.3.1 Regulations

There are several regulatory agencies and standards governing the storage and handling of chemicals. The following list identifies the bulk of these.

- Resource Conservation and Recovery Act (RCRA)
- Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA)
- Superfund Amendments and Reauthorization Act (SARA)
- Emergency Planning and Community Right-to-Know Act (EPCRA)
- International Fire Code (IFC) with COP Amendments
- National Fire Protection Act (NFPA)
- Arizona Division of Occupational Safety and Health (ADOSH)
- American National Standards Institute (ANSI)
- Phoenix City Code
- Water Services Department Environmental Health and Safety (EH&S) Standards

7.3.2 Tanks and Piping

Tanks, piping, valves, gaskets, etc. shall be constructed of materials compatible with the chemical they contain and transport. All tanks and piping shall be labeled and marked according to the chemical they contain and its hazard classification. Table 7.1 identifies the acceptable materials of construction for various portions of the tank and piping system.

Table 7.1: Materials of Construction for Lift Station Chemical Systems

Chemical	Tank	Piping	Gaskets	O-Rings and Seals	Valve Seats	Valve Diaphragms
Bioxide	FRP HDPE	Schedule 80 CPVC HDPE FRP	EPDM	EPT	EPT	N/A
Sodium Hydroxide	FRP	Schedule 80 CPVC	Teflon EPDM (Steel-steel flanges)	EPDM	Teflon	Teflon & EPDM (dual diaphragms)
Sodium Hypochlorite	FRP	Schedule 80 CPVC	Viton	Viton	Teflon	Teflon & EPDM (dual diaphragms)

The tanks shall be sized to store 30-days worth of their respective chemical. Each tank shall have a sight glass suitable for direct exposure to sunlight that indicates the level of the chemical inside the tank and that is visible from the chemical fill station. Sight glasses that contain chemical (as opposed to a float) must include isolation valves and a drain to facilitate replacement of the sight glass. In addition to a sight glass, each tank must have an ultrasonic level transducer installed to provide an independent measure of the liquid level in the tank. Level information must be sent to a transmitter located at the chemical fill station. The maximum full condition must be clearly labeled on the transmitter if the read-out is in any other unit than percent full.

A drain nozzle must be installed on each tank. This nozzle shall be flush with the bottom of the tank to allow for complete drainage of the tank. The feed pump suction line shall be separate from the drain line and shall include a basket strainer. The tank fill line shall include, at an appropriate location, a strainer, tee, and quick connect to allow for transfer of chemical from the containment area back into the tank after a spill. Each tank shall have a vent (with insect screen), which must be 2 pipe sizes larger than the fill line. Each tank shall also include an overflow, sized at least 1 pipe size larger than the fill line. When multiple tanks are used for the same chemical, the overflows shall be tied together in a common overflow header to allow one tank to overflow into the other. The header shall have an overflow piped to the containment area in the event both tanks are overfilled.

7.3.3 Containment

Containment areas shall be provided for scrubber units, chemical storage tanks, and chemical feed facilities. The containment area for Bioxide must be located at least 20 feet away from the containment areas for both sodium hypochlorite and sodium hydroxide. Each chemical storage tank shall be located in a separate, monolithically poured, concrete containment area with a protective (non-slip, non-porous) coating, resistant to the stored chemical and extreme heat. This coating shall be provided on both vertical and horizontal surfaces within the containment basin and shall extend across the top of the containment area wall to the outside face of the basin. The containment volume shall be designed to contain the 100-year, 24-hour storm event, and 100 percent of the total chemical storage tank volume plus 6-inches of freeboard. The floor of each concrete containment area shall be sloped to its own sump. The sump shall be self-contained and must not drain to the sewer or wet well. The only pipe that can be connected directly to the containment area sump shall be the pipe coming from the sump located in the respective chemical unloading area. The sump shall be emptied as necessary by portable pumps. All containment areas less than 4,000 square feet shall be covered by a fire resistant fabric shade structure. All materials, including pipe, concrete embeds, handrails, steps, hardware, nuts, bolts, etc., must be constructed of non-ferrous, non-corrosive materials and be suitable for exposure to the chemicals in question.

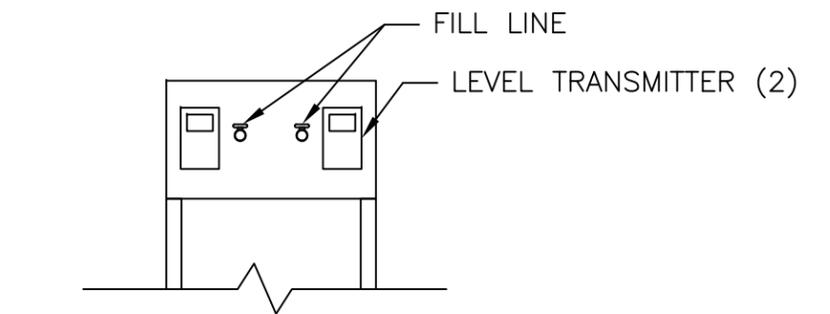
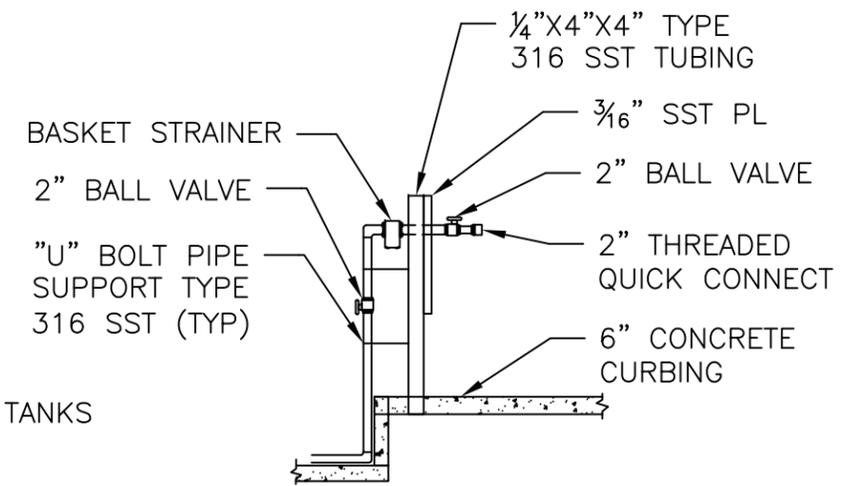
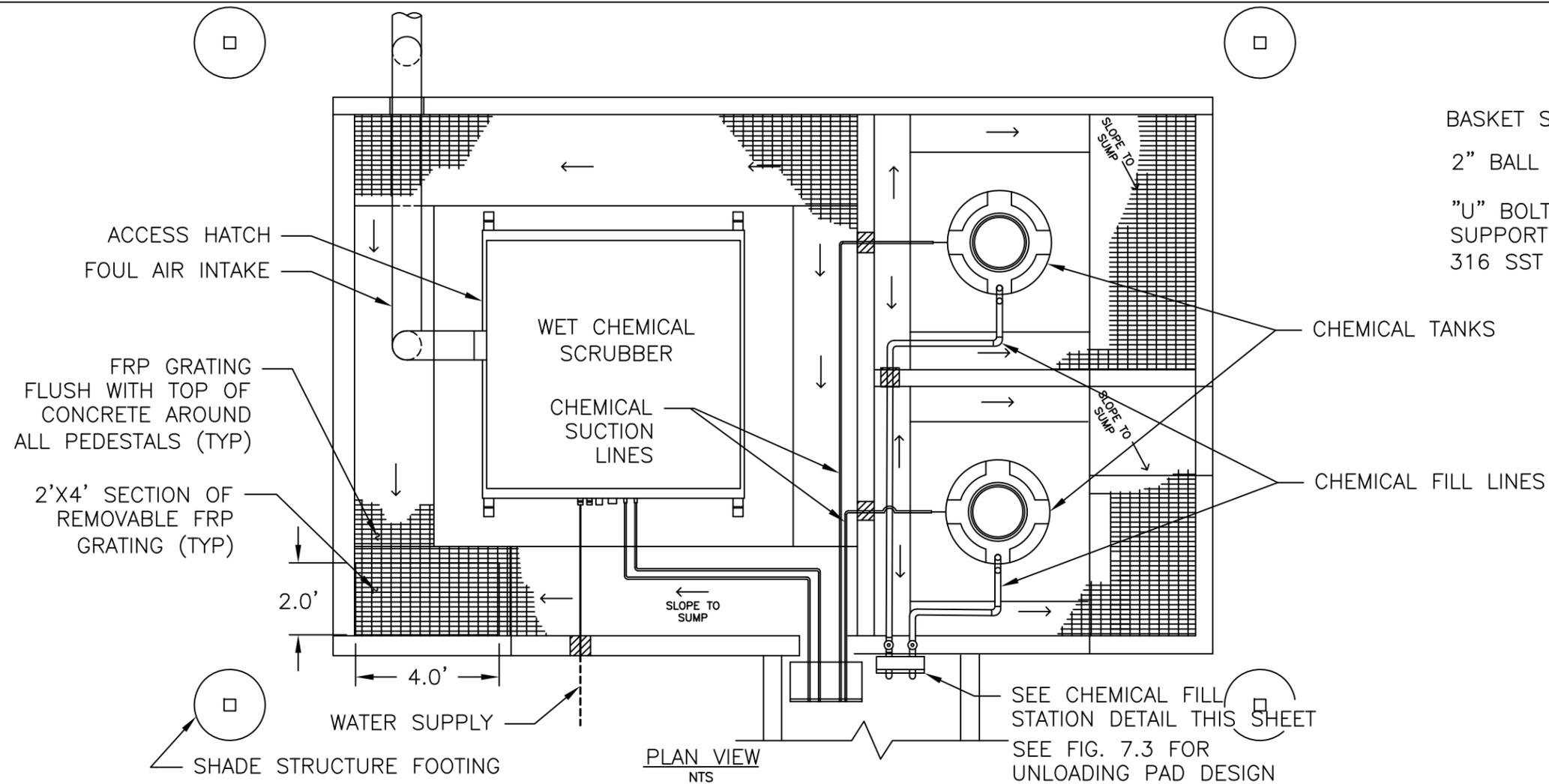
The following list provides additional design guidance for chemical containment areas.

- Depress bulk storage containment area sufficiently to allow for drainage from the truck unloading containment.
- All equipment pads and electrical/instrumentation conduits shall be elevated above the maximum liquid level.
- Chemical lines from the chemical feed/dosing pumps and chemical storage tanks must be routed within the containment area or within chemically protected leak-proof pipe trenches; otherwise, chemical lines shall be equipped with secondary containment.
- Provide FRP grating above all open areas of the containment basin to allow access to tanks, piping, pumps, etc. in the event of a tank rupture or spill.
- Provide a removable FRP panel above the containment area sump to allow for easy insertion of portable sump pump(s).
- Any piping that leaves the containment basin must be double contained. The containment piping must be open on both ends and be routed and sloped in such a way as to allow any chemical leaked from the carrier pipe to drain back to the respective containment basin.
- Penetrations of the containment basin must be kept to a minimum. Any penetrations that are necessary must include a water stop that is compatible with the respective chemical.

See Figure 7.1 and 7.2 for acceptable containment basin designs.

7.3.4 Chemical Unloading

Each tank shall have an associated chemical unloading pad and fill station. The pad shall be designed to contain a minor spill from the chemical delivery truck and route it to the



NOTES:

1. BIOXIDE CONTAINMENT BASIN ONLY REQUIRES ONE CELL.
2. PROTECT LEVEL TRANSMITTERS FROM DIRECT EXPOSURE TO SUNLIGHT.

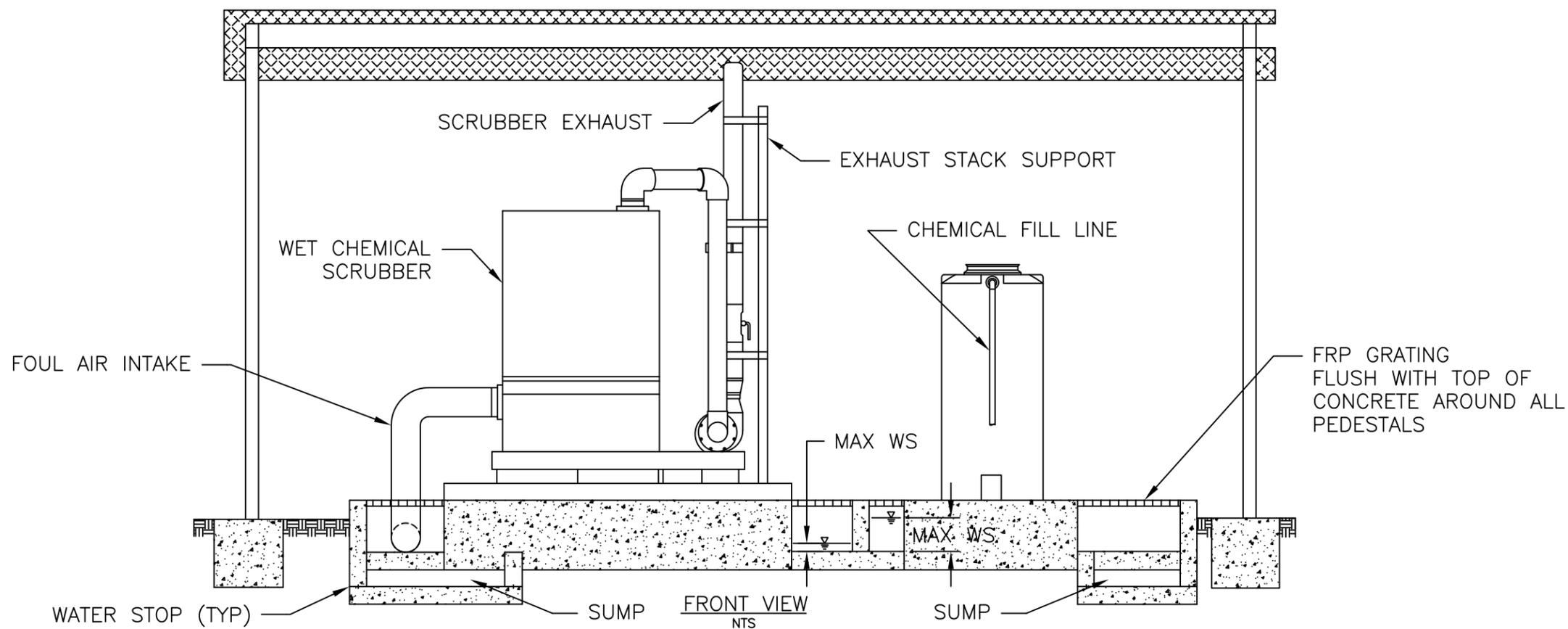
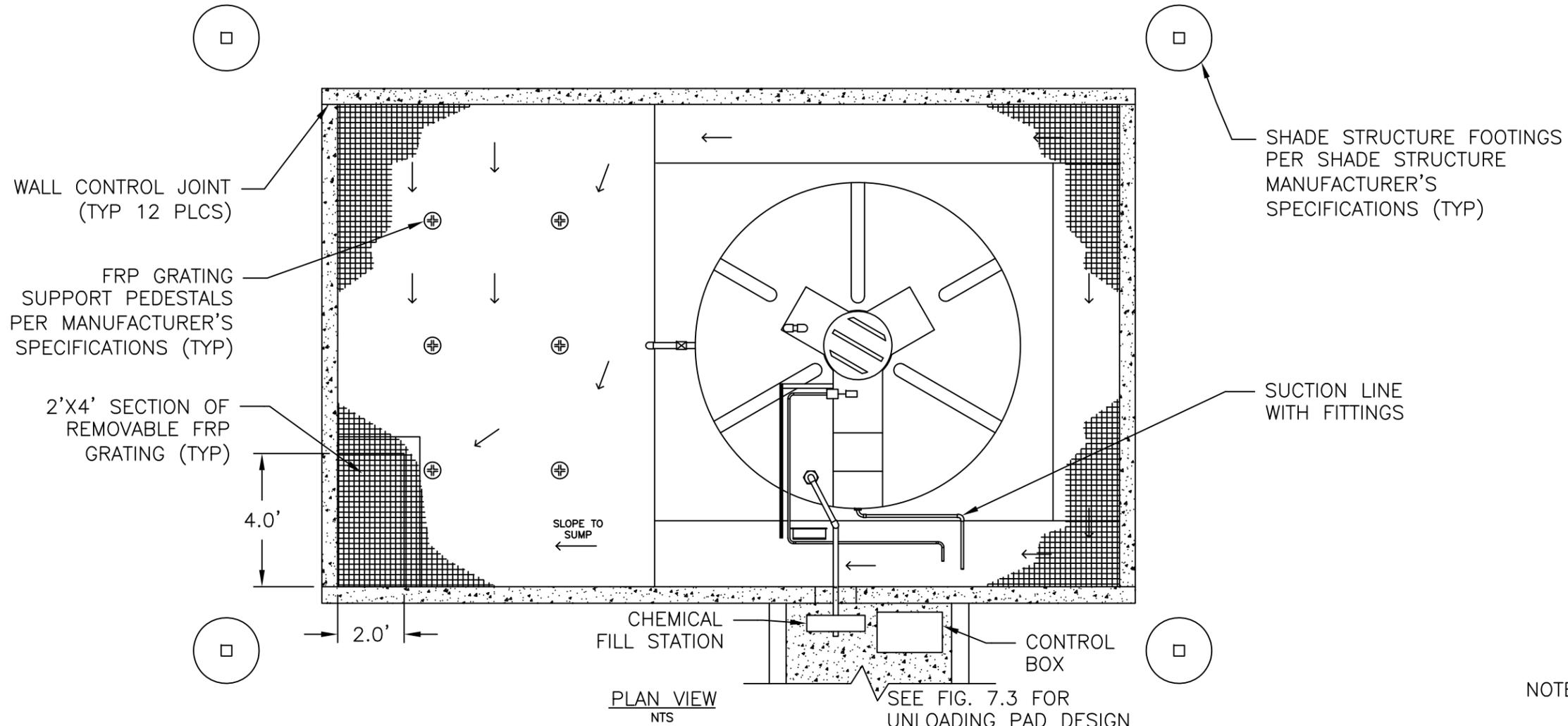


FIGURE 7.1:
TYPICAL CHEMICAL
CONTAINMENT BASIN DESIGN



NOTES:

1. SHADE STRUCTURE SHALL BE ULTRAVIOLET AND FIRE RESISTANT FABRIC. FABRIC SHALL BE SECURED WITH SNAP FASTENERS.
2. THE SHADE STRUCTURE COLOR SHALL MATCH THE PERIMETER WALL AND BE DRY OUTPOST OR AS DIRECTED BY THE CITY OF PHOENIX.

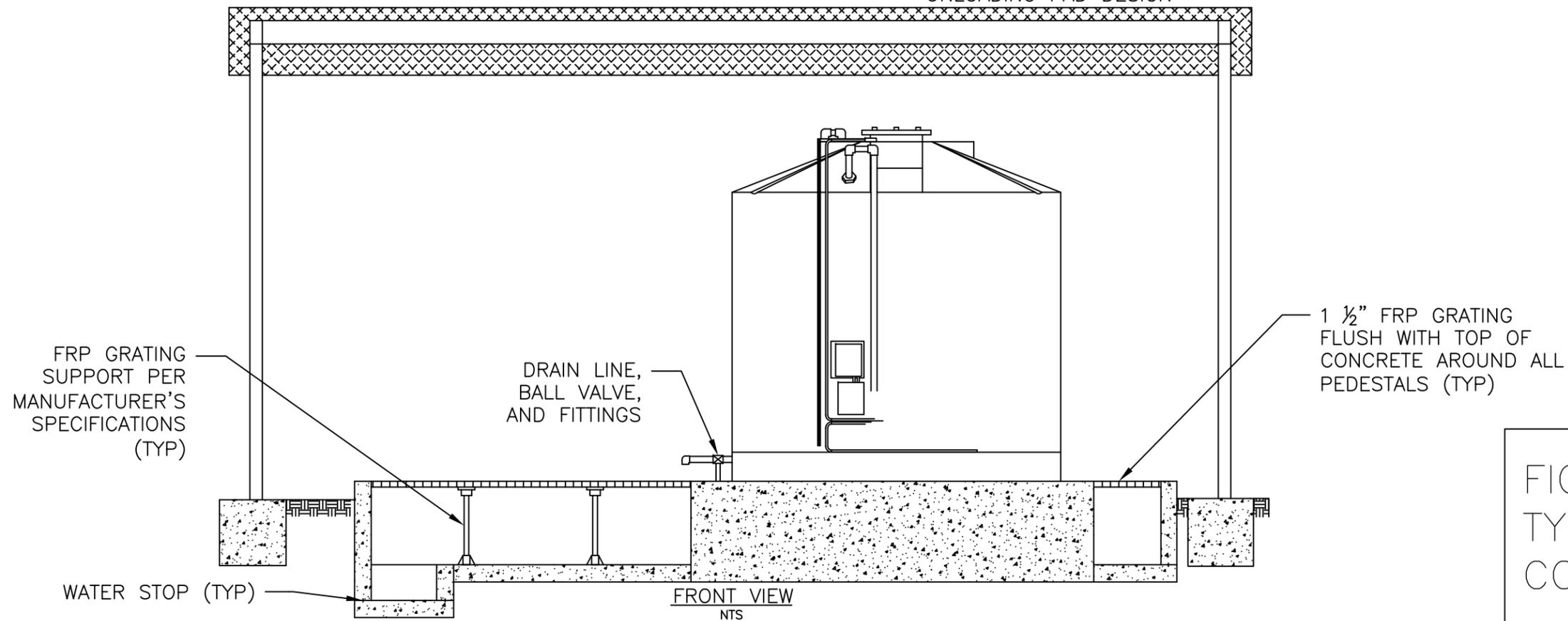


FIGURE 7.2:
TYPICAL BIOXIDE
CONTAINMENT BASIN DESIGN

proper containment basin. The fill station shall include a small containment sump that drains into the containment basin as well. Both of these areas shall be coated with an appropriate coating, similar to that used in the containment basins.

Fill stations shall be constructed adjacent to the chemical unloading pad. These stations shall provide for a centralized location to fill all the tanks in the associated containment basin. The stations shall consist of a stand to support the tank fill lines and will be of sufficient size and structural integrity to support the level transmitters for each tank. The transmitters shall be mounted directly above or adjacent to the fill line for their respective tanks and be shaded from direct sunlight. Each tank fill line shall consist of a threaded quick connect, isolation ball valves and a basket strainer. The fill station and all associated fill lines must be provided with appropriate secondary containment.

At a minimum, a combination eye wash and emergency shower station equipped with an anti-scald valve shall be located immediately adjacent to each fill station. The path from the fill station to the eyewash station shall be free of any obstacles or tripping hazards. Control panels and other electrical equipment shall be located a safe distance from the eyewash station.

See Figure 7.3 for an acceptable unloading pad and fill station design.

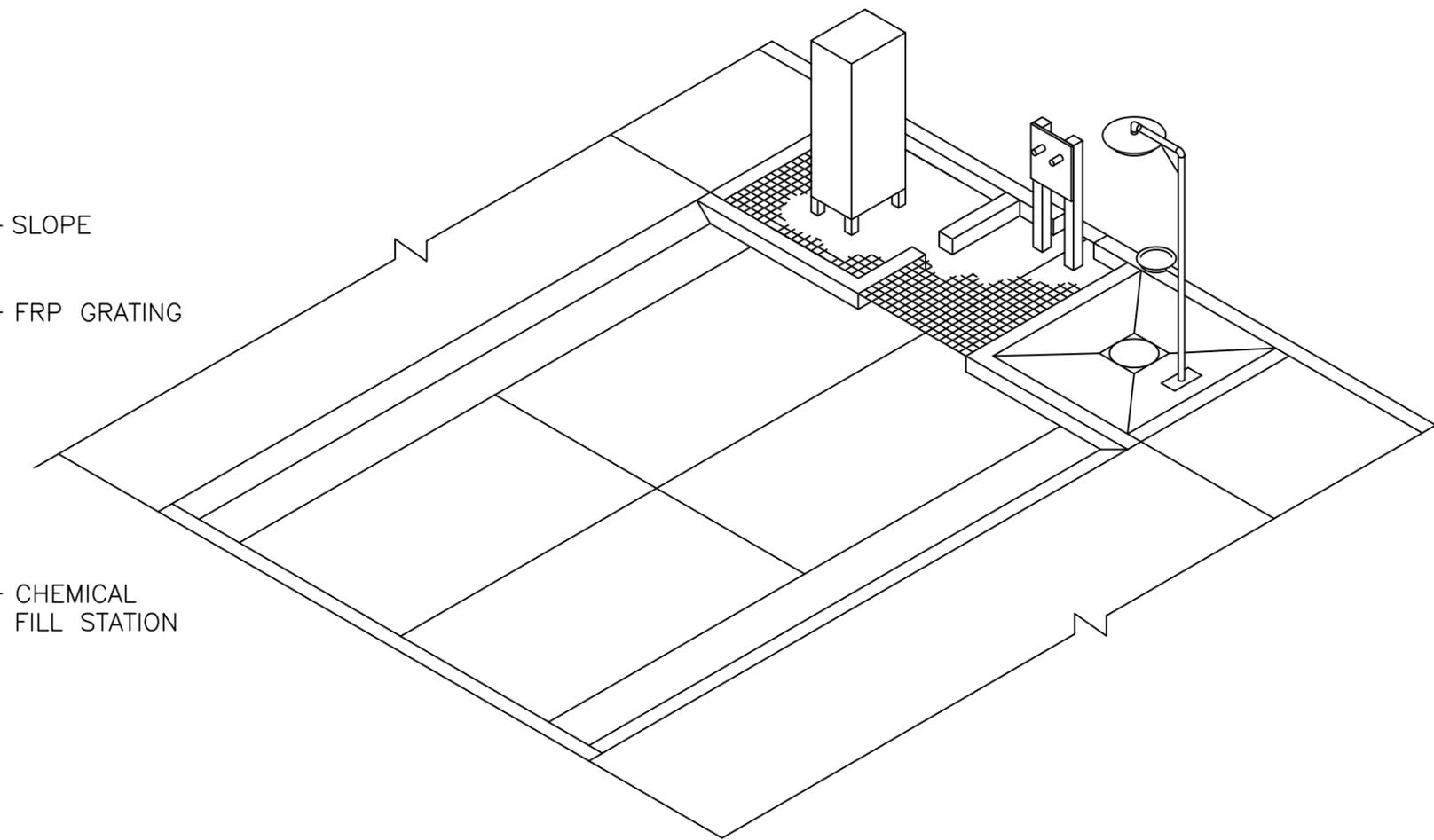
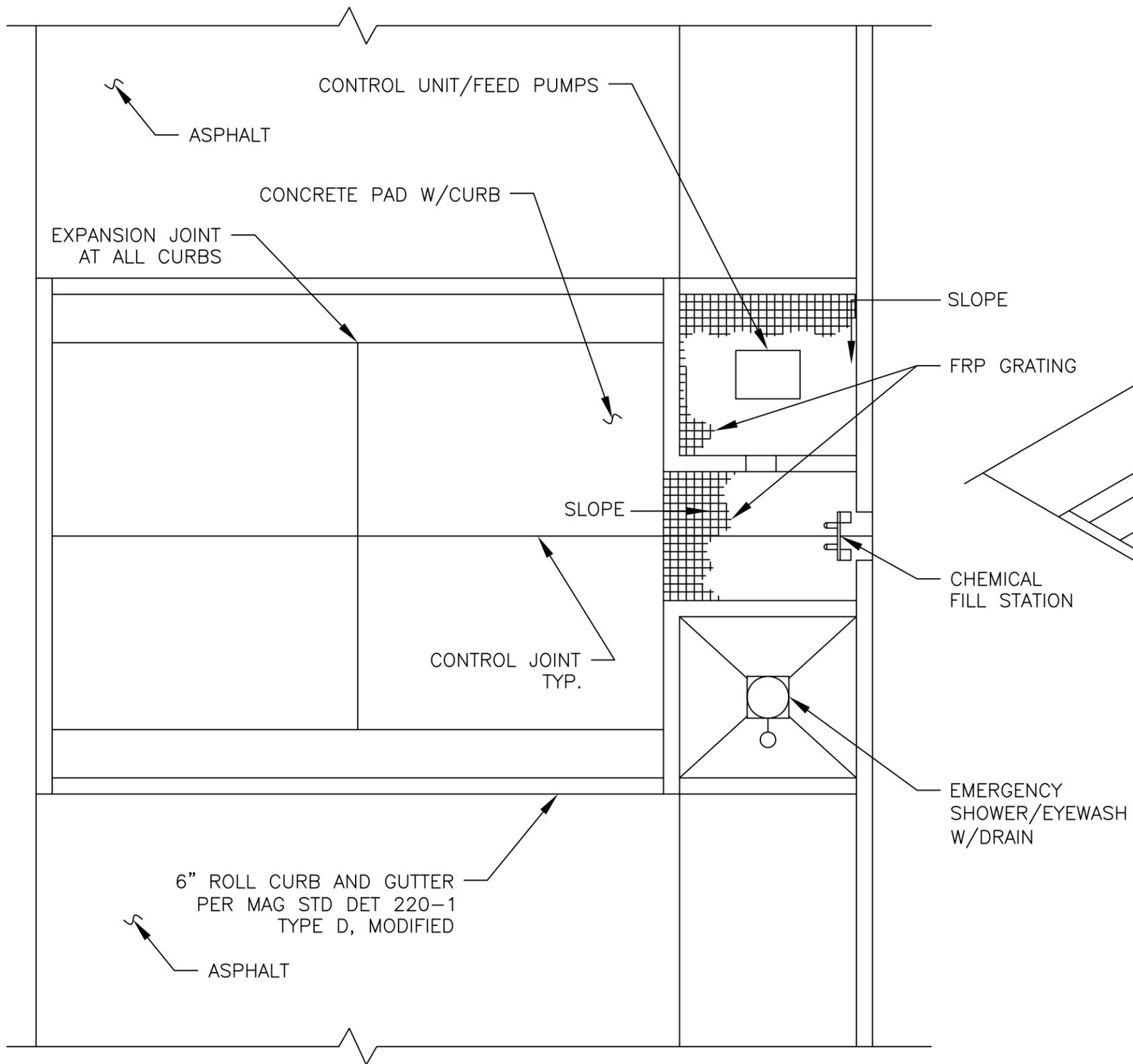


FIGURE 7.3:
 TYPICAL CHEMICAL
 UNLOADING PAD DESIGN

SECTION 8 - ELECTRICAL SYSTEM

This section provides general design criteria for the design of a wastewater lift station's electrical system. The design criteria presented in this manual are not all inclusive, but are intended to serve as a guide to the uniform design of wastewater lift stations for the City and to supplement the design information provided for pumping facilities in the City of Phoenix Design Standards Manual for Water and Wastewater Systems, and MAG Standard Specifications and Details.

Coordination with the electric utility regarding the electric power supply voltage, transformer ownership, motor starting limitations, and metering requirements are crucial factors in the electrical design of a project and must be initiated very early in the design of the project.

8.1 General Design Guidelines

The electrical systems for wastewater lift station designs shall comply with the National Electrical Code (NEC), City code, and all applicable local codes. The electrical equipment will be manufactured in accordance with the standards of the Institute of Electrical and Electronic Engineers (IEEE) and the National Electrical Manufacturers Association (NEMA) and shall be listed by the Underwriter's Laboratory (UL). The electrical equipment will require a "label" indicating compliance with the standards of the applicable codes.

The electrical design will include service entrance sections, switchgear sections, motor control sections, VFD cabinets (if required), standby and/or dual-power systems, control panels, conduit and wiring. In general, the electrical equipment specified shall be suitable for outdoor installations, mounted on concrete pads. VFD cabinets must be housed in an air-conditioned building. If larger pumps are to be added in the future and/or the station is to otherwise be expanded, oversized conduits, cabinets, floor space, and additional conduits shall be provided to meet the future needs. Each design shall include power demand information for the City of Phoenix to apply for the electrical service from either the Salt River Project (SRP) or Arizona Public Service (APS) power companies, depending on the location of the project.

Utility company equipment, namely the main site transformer, shall be located outside of the site fence. The engineer shall coordinate the design with the servicing utility company to determine the most convenient way for the company to access their equipment and meters given WSD's security requirements.

8.2 Standby Power Systems

Two separate independent sources of electrical power must be provided to each wastewater lift station. The primary source shall be commercial power from either utility substations or transmission lines. The standby power source shall be from an on-site, natural gas/diesel-fueled engine generator tied to the on-site distribution system. Natural gas is preferred where readily available. For phased facilities, the study must address the need to supply standby power for the ultimate pump station configuration.

The standby power source shall be 100% the capacity of the primary power source. For diesel-fueled generators, adequate fuel supply must be provided to ensure operation of the lift station for an extended period of time. The period of time will be determined during design and will depend on the amount of fuel required and regulatory requirements. In no case shall that period of time exceed 72 hours. In addition, diesel generators must have a double-contained, above ground fuel tank and the engine shall have a maximum governed speed of 1,800 rpm. See paragraph 6.9.2 for noise standards associated with the generator.

The generator installation shall be depressed (if necessary) to be below the height of the station perimeter wall. In no case shall the generator installation be depressed more than three (3) feet. Adequate flood protection measures shall be designed into the depressed generator design to ensure protection against flood hazard. All units shall be four cycle units complete with sound enclosures and hospital grade exhaust silencers. Complete generator characteristics must be included or referenced in the specifications.

Each station shall be designed with an Automatic Transfer Switch (ATS) rated for 100% of the full load power requirement of the station. This switch shall be located downstream of the SES Panel, utility power meter, and the main disconnect switch. The ATS shall conform to the requirements of NEMA Standard ICS 2-447 and Underwriter's Laboratories UL-1008. For sites deemed critical, a Manual Transfer Switch may also be required for connection of a portable generator.

8.3 Power System Protection

Wastewater lift stations will operate unattended. Therefore, their power systems shall be provided with protection against single phasing, improper phase rotation, ground faults, and power surges that may come in on the power lines such as from lightning strikes.

Fault studies analyzing the available fault currents shall be prepared for each source of power. Note that the normal standby engine generator can only provide a fault current of three times its full load current or less. Faults shall report to the Programmable Logic Controller (PLC) and alarming (Autodialer) system.

A coordination study for selection of proper protective devices shall be performed for each installation. If one of the sources is an engine generator, special care shall be taken in selecting fault protective devices to ensure their operation when the station is being powered by its alternative power source (engine generator).

A TVSS shall be factory installed in the SES and another shall be installed between the generator's main breaker and the ATS. Each TVSS shall have a dedicated disconnect switch to allow for maintenance or replacement without shutting power down to the entire site.

8.4 Uninterruptible Power Supply

An uninterruptible power supply shall be provided for critical loads where failure of equipment to operate satisfactorily would jeopardize the health and safety of personnel or safety of station systems. Examples include the station's PLC, alarming (Autodialer) system, and some instrumentation and control systems.

8.5 Equipment Sizing and Rating

Equipment and materials shall be rated to withstand and/or interrupt the available fault current, with at least a 20% reserve margin for electrical load growth. Electrical power conduits shall be sized for ultimate design conditions as discussed in Section 8.1. Electrical power conduits shall not be installed in the same duct bank with instrumentation and control conduits.

For conduits installed in concrete or under base slabs, etc., the design consultant shall provide and stub-up at all major equipment and panels at least two spare conduits for every 10 placed. The minimum size of the spare conduits shall be 1-inch diameter. These spares are not for anticipated future expansion but to permit installation of additional ancillary equipment if desired.

8.6 Motor Control Centers, Switchgear, and Electrical Panels

All motor control centers (MCC's), switchgear, and electrical panels shall be provided with a solid state-monitoring device as a minimum. A fire resistant shade canopy shall be provided for all electrical panels. If shade canopies cannot be supplied, factory installed venting or cooling shall be provided

SECTION 9 - INSTRUMENTATION AND CONTROL

The entire Instrumentation and Control system for the City of Phoenix lift stations centers around a Programmable Logic Controller, or PLC. This device provides automatic control of various lift station systems, collects and transmits data about lift station processes, and identifies and communicates alarm conditions. The majority of sites shall include one PLC. Redundant control is also required and the majority of sites accomplish this through the use of less sophisticated systems. However, sites deemed critical may require installation of a redundant PLC and associated hardware.

Although not currently utilized, the PLC must be capable of integrating with a front-end control interface that would allow for remote alarm monitoring and modification of system set points.

9.1 Control Systems

Lift Stations in the City of Phoenix are intended to be unmanned sites. Therefore, automatic control systems are required to control standard functions at the lift station. The two main systems are pump control and security.

9.1.1 Pump Control

The Pump Control Panel (PCP) operates the lift station automatically, provides personnel with status indicators, data recorders, and control switches, and allows automatic or local control.

The pump control system is primarily controlled by wet well level transmitters. Each wet well shall include two ultrasonic level transmitters; a primary and a backup. The primary indicator communicates level information to the PLC, which uses its programming to decide if the pumps need to turn on or off. The PLC then sends the appropriate signal to the PCP. The backup transmitter communicates level indication to the PLC and is used as a backup local controller for the PCP in the event the PLC is off-line.

9.1.2 Security

The main element of security at lift stations is access control. This control is primarily accomplished through the use of card readers and automated gates. WSD has created stand-alone security design guidelines that provide detailed explanations of the system components and intended operation. The design engineer will need to request a copy of these guidelines prior to designing a security system for the site.

9.2 Instrumentation

The following sections will identify the instrumentation that WSD requires and the signals and alarms from those instruments that the WSD uses for the operation and monitoring of lift stations.

9.2.1 Instruments

Table 9.1 identifies the required instruments, the location that the instruments will be installed, and the equipment that instruments are connected to. All field mounted instruments must be protected from exposure to direct sunlight.

Table 9.1: Instrumentation

Instrument	Location	Equipment	Notes
Temperature Sensor	Field	Pump	
Moisture Sensor	Field	Pump	
Level Element	Field	Wet Well, Chemical Tanks	
Pressure Transmitter	Field	Force Main	Provide one transmitter for each pump discharge pressure.
Pressure Gauge	Field	Force Main	Provide one gauge for each pump discharge pressure.
Flow Element	Field	Force Main	
Level Transmitter	Field/PCP	Tank Level Element/Wet Well Level Element	
Flow Totalizing Transmitter	PCP		
Flow Totalizer	PCP	Flow Totalizing Transmitter	Typically consists if a Relay-Output contact integral to the Flow Totalizing Transmitter
Transient Voltage Surge Suppressor	MCC	MCC	
Temperature Transmitter	PLC	PLC	PLC cabinet temperature indication

9.2.2 Process / Alarm Status Indication

Table 9.2 provides a list of the required process / alarm status indications and their indication points.

Table 9.2: Process / Alarm Status Indicators

Status / Alarm Indicator	Indication	Notes
Pump Fault (High Temperature, Moisture, Overload,)	Lamp on PCP, PLC, Autodialer	For each pump. Overload, RVSS Fault or VFD Fault should be utilized as applicable.
Pump Run Status	Lamp on PCP, PLC	For each pump.
High Wet Well Level Alarm	Lamp on PCP, PLC, Autodialer	
Wet Well Level	PLC	Two level transmitters should

Indication		be installed in the wet well for redundancy purposes. Both should input to the PLC. The second transmitter will act as the backup local controller via integrated relay output contacts in the event of a PLC failure. The hard-wired control logic should be integrated in a way that the backup transmitter bypasses PLC control upon the detection of high wet well level alarm.
Force Main Pressure	PLC	
Flow Rate Indication	PLC	Flow Totalizing Transmitter should be installed in such a way that the display is visible upon gaining access to the PCP. If this is not possible due to space constraints, then a local indicator should be installed on the PCP along with the pump controls.
Flow Rate Total	PLC, PCP	Flow total indication should be installed on the PCP as well as input to the PLC. Typical PLC input is 1 Pulse = 1000 gallons.
Generator Fault	Lamp on PCP, PLC, Autodialer	
Station on Generator Power	Lamp on PCP, PLC, Autodialer	
Station in Maintenance Mode	Lamp on PCP, PLC	
Station in Auto Mode	PLC	
Station in Local Control	PLC	
Odor Control System Fail (Blower, Recirculation Pump, Control Power, Ph out-of range, ORP out-of-range)	PLC, Autodialer	
Odor Control Blower Run Status	PLC	
Odor Control Recirc Pump Run Status	PLC	

In addition, a Push to Test button shall be installed on the PCP that tests the function of all indicating lamps within the panel.

All process related alarms at the site are reported through an autodialer that is installed in the PCP. Intrusion alarms may also be routed through the autodialer depending on the sophistication of the security system. The following is a list of the required alarms.

- Control Power Failure
- Pump Failure (for each pump)
- Generator Failure
- High Wet Well Water Level
- Low Wet Well Water Level
- Station on Standby Power
- Odor Control System Failure
- Entrance Gate Intrusion (All vehicle entrance and man gates)
- Electrical Panel Intrusion (All MCC / SES / ATS / PCP / PLC doors)
- Generator Intrusion (If the site is equipped with a permanent standby generator, all doors should be alarmed.)
- Generator Low Fuel
- Generator Fuel Leak

All process alarms, pump run time and flow totalizers shall be resettable at the PCP. High Wet Well Level Alarm, pump run-time and flow totalizers should also be resettable remotely via the PLC. Any security alarms will be routed and terminated per the WSD Security Guidelines.

9.3 Communications

Communications to and from the site shall be accomplished via standard telephone lines. A minimum of three (3) phone lines shall be installed: one for a site telephone, one for the autodialer, and one for a modem used for PLC communications. In addition, provisions shall be included in the PLC panel for installation of a future spread spectrum radio or connection to a City-owned fiber optic network, if one is available.

A PLC panel interface, containing a power receptacle, RS232 and ethernet connections, must be installed on the door of the PLC panel to facilitate a wired connection between the PLC and a laptop computer without having to open the PLC cabinet.

SECTION 10 - SITE LAYOUT

This section of the Design Manual is meant to give general guidance on the layout of the site from a functional standpoint. Storm water retention requirements, grading and drainage, set-backs, etc. are governed by codes and City ordinances and are reviewed during plan review by the Planning and Development Department (see Section 2).

10.1 Facility Location

Generally, the City prefers that the property the lift station occupies be large enough to provide at least a six (6) foot buffer around the station's perimeter wall and that the station be somewhat centered in that property. This location separates the station from the nearest property owners and therefore reduces the likelihood of complaints from neighbors. The addition of low-maintenance landscaping surrounding the entire lift station will further blend the station into the neighborhood, although security concerns must be considered. The designer should initially consider this "centered location" for the orientation of the lift station and adjust or modify accordingly to satisfy project constraints, etc.

10.1.1 Setbacks

Setbacks from adjacent property and/or Right-of-Way lines will be governed by P&D and the most current edition of the IBC. These two resources should be consulted for determination and specific information about the setback requirements. In addition, the designer should consult the City zoning ordinance for restrictions associated with the zoning classification.

10.1.2 Ingress/Egress

Site layout shall be designed to allow adequate access for an FHWA Class 9 delivery truck to the facility while providing minimal traffic disruption. Whenever possible, the entry/exit gate(s) should be positioned far enough from the right-of-way (out of traffic) to allow such a delivery truck to be parked while a worker opens the gate. The gate(s) and driveway(s) must also meet City Fire Department criteria. These requirements typically dictate gate and driveway width, but may also affect turning radii within the site. A turning lane for ingress/egress to the facility may be required if a site is located on a heavily traveled roadway. This requirement should be discussed at length with the City of Phoenix Street Transportation Department and the WSD. Access to facilities on corner lots shall be provided by the street with the lowest traffic volume.

10.2 Internal Layout

Wherever possible, a looped access road around the wet well should be provided. If size limitations do not allow this, the access road should provide the ability to enter and exit the site without having to back directly into a street. The access road shall also include a driveway or similar paved area that allows personnel to access the pumps with a truck-mounted crane from a paved surface. However it is configured, the access road must be designed to accommodate the aforementioned Class 9 delivery truck or to meet Fire Department requirements, whichever is more restrictive. To obtain general information on the City of Phoenix Fire Department process and procedures call (602) 262-6002. It is

recommended that the designer meet with a Fire Department representative to obtain details regarding all applicable design standards.

Bollards or other acceptable protection devices must be installed to protect all equipment, piping, shade canopies, electrical devices, etc. from vehicular traffic.

10.2.1 Chemical Storage and Containment

The chemical storage and containment areas shall be directly adjacent to the looped access road to facilitate safe and easy delivery of chemicals. See Section 7 for additional information about chemical unloading areas and separation requirements.

10.2.2 Electrical Equipment

The electrical equipment shall be arranged in a line and be located in close proximity to the wet well. For a typical layout, this will put the electrical lineup inside the access loop. Bollards or other protective structures must be installed around the lineup in sufficient number to protect it from potential damage caused by delivery trucks or maintenance vehicles.

The emergency generator can be placed anywhere within the perimeter wall of the site. However, if the generator is diesel powered, it must be located in such a way as to avoid a direct drainage path to any dry wells installed at the site. In addition, the designer must consider noise restrictions and ease of access when siting the generator.

10.2.3 Storage and Buildings

The designer shall provide space for a lockable storage container at all sites. The size of this container will vary based on the capacity of the lift station and the equipment being utilized, but can be as large as 10 ft by 20 ft. In addition, a storage cabinet for Operations and Maintenance manuals and log books shall be installed at the end of the electrical lineup.

For sites that utilize VFDs, an air conditioned building will be required. Since this is not a typical design for WSD, engineering and field staff will work with the designer to determine the location of the building within the site and the layout of the building itself.

Typical site layouts and/or schematics for wastewater lift stations are shown in Figures 10.1 through 10.3. These figures show approved layouts and are provided to improve understanding of the requirements identified above. They are not meant to be used as “cookie cutter” templates for future lift stations.

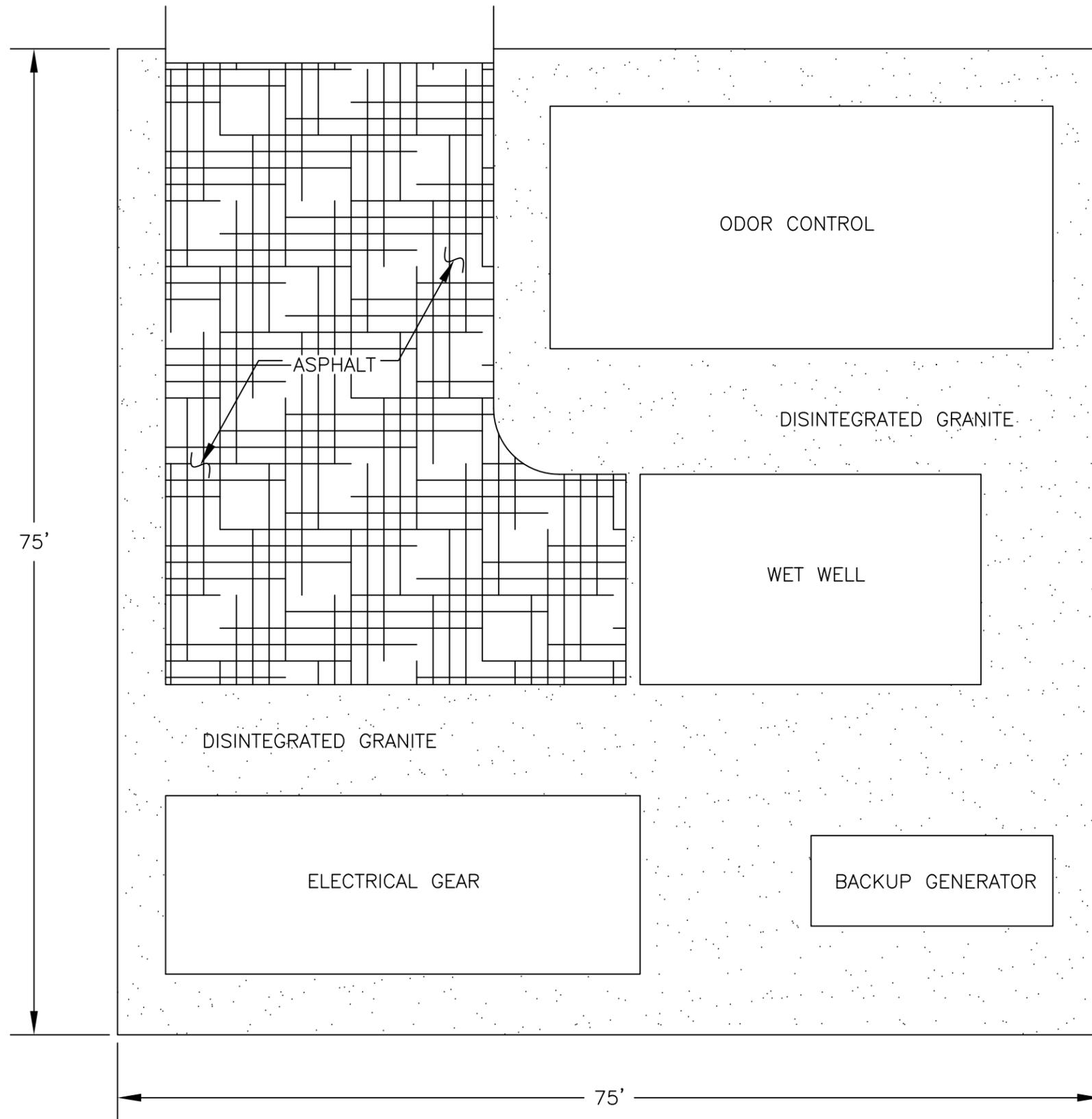


FIGURE 10.1:
TYPICAL SMALL LIFT STATION
SITE LAYOUT

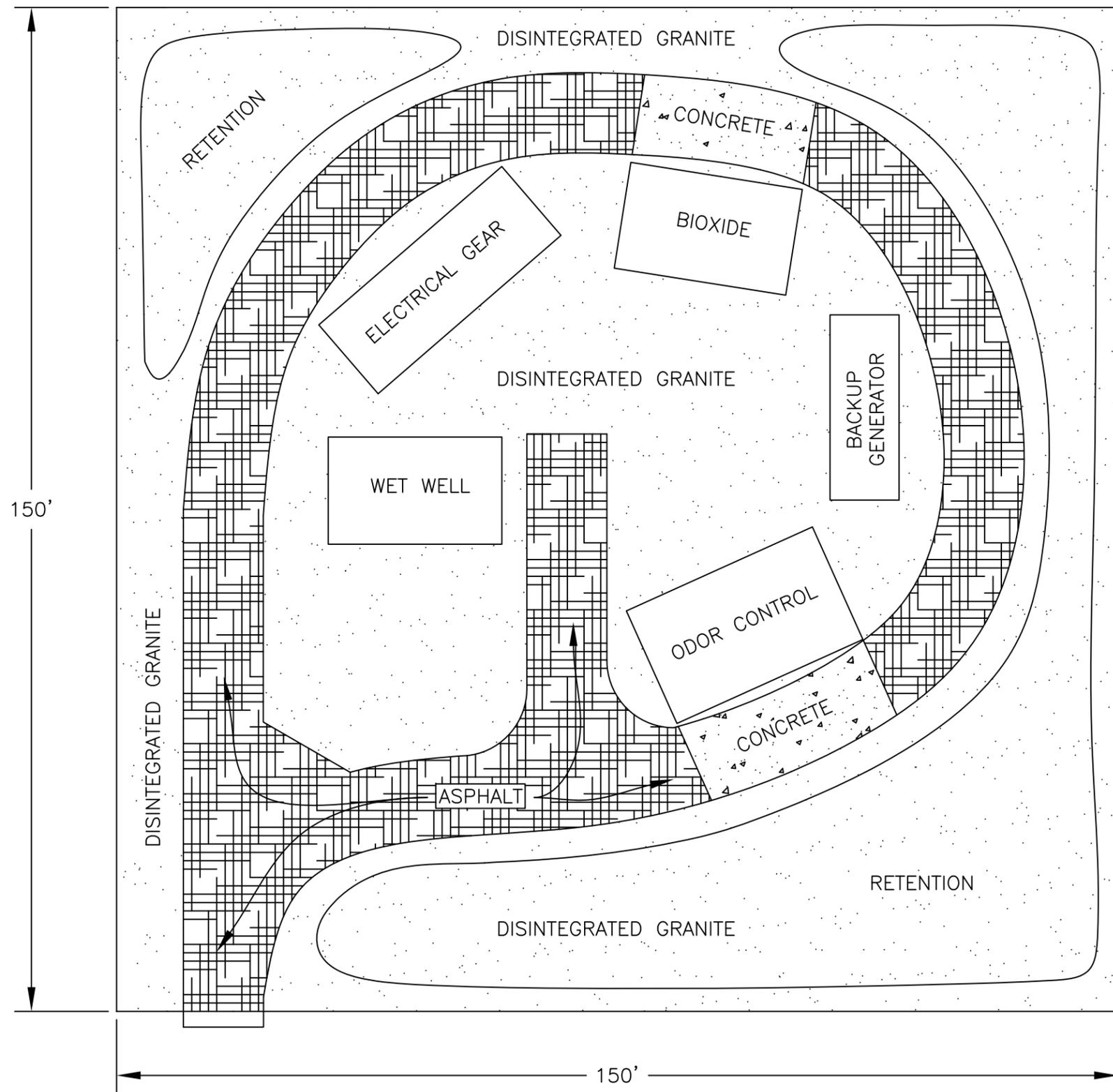


FIGURE 10.2:
 TYPICAL MEDIUM
 LIFT STATION SITE LAYOUT

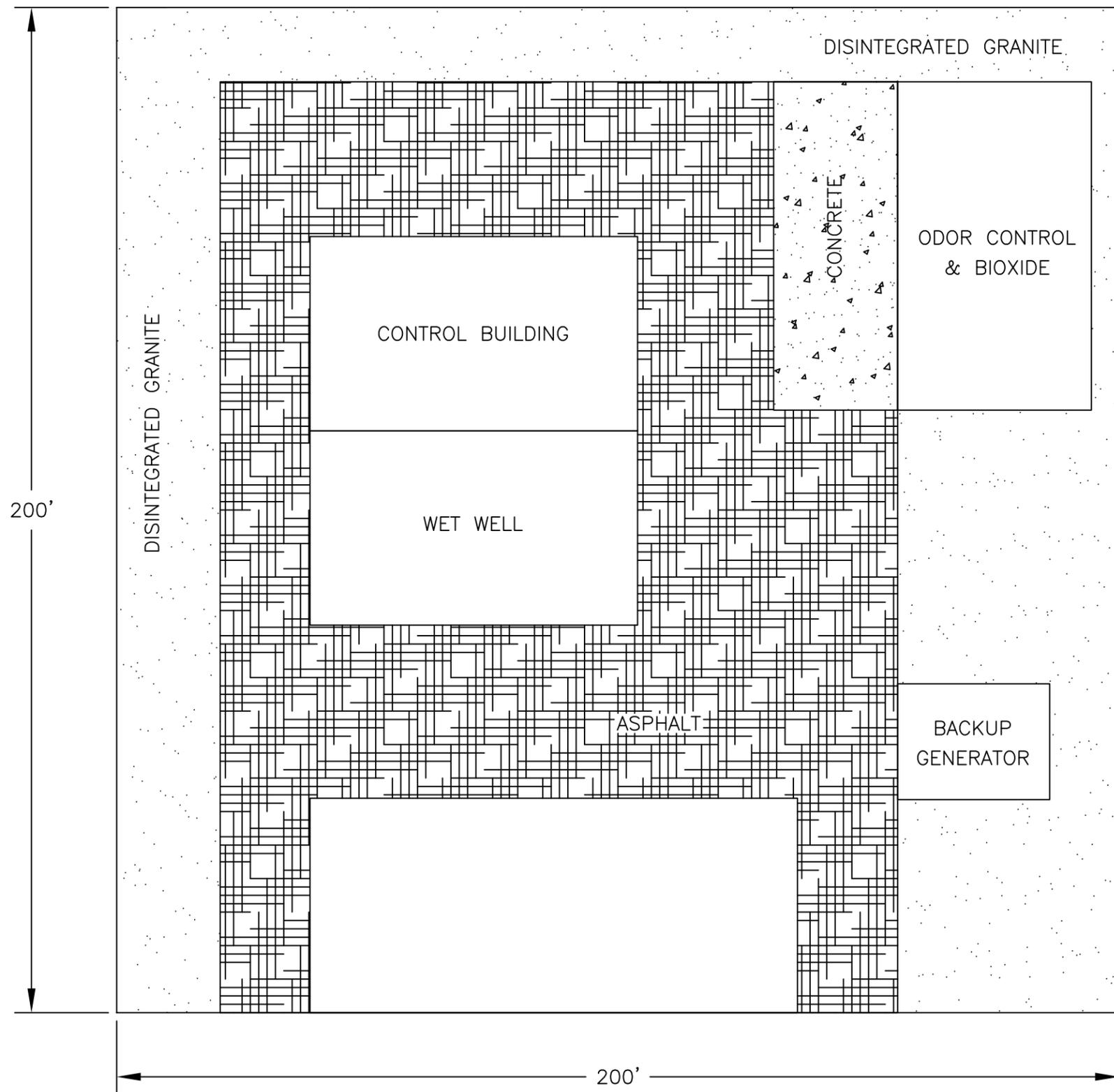


FIGURE 10.3:
TYPICAL LARGE
LIFT STATION SITE LAYOUT

SECTION 11 - ARCHITECTURE AND LANDSCAPING

More often than not, lift stations are located either in or in close proximity to residential communities and commercial centers. Therefore, consideration must be given to the outward appearance of the site. While WSD will have some requirements relating to security and maintenance, the Planning and Development Department (P&D) will provide the majority of the architectural and landscaping requirements. However, due to the different processes development plans can go through, these requirements may not be communicated until the plans are submitted for permit review. To help avoid significant changes during permit review, it is recommended that the designer visit the Site Development counter in P&D early in design.

11.1 External Features

External criteria shall incorporate the theme of the surrounding community into the aesthetic design of the station. Form, style, materials of construction, colors, and finishes should reflect that theme. The underlying intent of the external architectural treatment of a facility is to have it blend in with the surrounding community/neighborhoods while maintaining a level of security. In some cases, an artist may be commissioned to add elements of public art to the walls, gates, and/or landscaping. Established City standards, preferences, and guidelines for materials, building layout, site security, and appearance should also be discussed and integrated into the design.

11.2 Internal Features

The primary internal design features will focus on the location and configuration of the selected processes within the station footprint, size of major pieces of equipment and their interdependency on adjacent mechanical and electrical systems, and their operation and maintenance. This was discussed in detail in Section 10. Any buildings on the site must incorporate design elements of surrounding buildings or development if they exist.

11.3 Lighting

The lighting design shall satisfy the operational needs of the facility. Interior ambient light levels shall be established for optimum safety and efficiency. Task lighting shall be provided for the electrical lineup, odor control systems, and instrument panels and shall be controlled via a toggle switch located in a convenient location (such as a shade canopy column). As a minimum, task lighting shall provide adequate lighting for the safe and efficient maintenance and operation of equipment at night. Interior of buildings and enclosures will be provided with four-foot fluorescent lights: Low-pressure sodium lighting is prohibited.

Site lighting shall be provided using wall-mounted lights around the site perimeter. These lights will be controlled by a toggle switch located directly inside the gate. Exterior lighting criteria shall be established to accommodate all necessary nighttime operations and assure a reasonable level of security for the facility. At the same time, exterior lighting criteria shall avoid illumination levels that are a nuisance to the surrounding community per the requirements of Shielding and Filtering Outdoor Lighting (“Dark Sky”), City Code Section 23-100.

11.4 Gates and Perimeter Wall

The City prefers having one gate for access to the lift station. This means that there must be enough room for a fire engine or chemical delivery truck to turn around within the station. The height of all lift station perimeter walls shall be 8 feet and shall be compatible with the surrounding environment. The 8 foot height requirement will most likely require a variance from the zoning department. CMU block is the most typical material of construction for the perimeter walls. There may be some variance in materials depending on the level of community and/or artist involvement in the project but in all cases the walls shall be easy to maintain.

Lift station access gates shall be automatic rolling gates. Swing gates are acceptable, but only where a rolling gate is not practical. In addition, the gates must sit 3-inches above finished grade and be 20 feet wide to allow for fire engine and chemical delivery truck entry. WSD's Remote Facility Security Design Guidelines provide additional detail regarding controls, locks, alarms, signs, and security implements.

11.5 Signage

Several different types of signage are required both inside and outside of the lift station. The following is a typical list:

- An identification sign shall be installed on the entry gate(s) and shall include the lift station number, address, and emergency contact phone number
- NO SMOKING signs shall be installed on each corner of the wet scrubber containment area and at each access point to the wet well
- NFPA 794 Information Diamonds shall be installed on each chemical tank along with a sign indicating the chemical being stored and its concentration
- DANGER EQUIPMENT STARTS AUTOMATICALLY signs shall be installed near any equipment that may be remotely started. At a minimum this includes:
 - Chemical recirculation pumps
 - Bioxide system
 - Emergency generator
 - Automatic Transfer Switch
- DANGER NON-POTABLE WATER signs shall be installed on or near all hose bibs
- Chemical metering pumps shall be identified with the chemical they pump. Bellows pumps shall also have the stroke labeled.
- All piping connections to equipment shall be labeled with the fluid they contain
- Gate and wall signage is identified in the WSD Remote Facility Security Design Guidelines.

See Figure 11.1 for examples of typical signage.

Figure 11.1: Sample Signage

SITE IDENTIFICATION



NO SMOKING



CHEMICAL WARNING SIGNS



Figure 11.1: Sample Signage (cont)

DANGER EQUIPMENT STARTS AUTOMATICALLY



NON-POTABLE WATER



CHEMICAL METERING PUMPS AND PIPING CONNECTIONS



11.6 Landscaping

In projects where landscaping is required, the design consultant shall utilize the services of a registered landscape architect (RLA). Landscaping materials, plantings, etc. shall be provided in accordance with local codes and ordinances and with the most current edition of the American Nursery Association Standards. Applicable local codes and ordinances include:

- “Hillside Ordinance,” Section 710 of the Phoenix Zoning Ordinance
- Landscape Standards and Guidelines City of Phoenix
- Arizona Department of Water Resources Low Water Use Plant List Phoenix Active Management Area (AMA)
- City Water Conservation Ordinance, Chapter 37, Article IX

Landscaping plans are reviewed through the City’s Development Services Department. Specific issues regarding landscaping and site security around the lift station should be addressed prior to submitting plans for permitting.

11.6.1 Plant Inventory and Re-Vegetation Design

The RLA shall prepare an on-site inventory (vegetative plan and de-vegetative plan) of desired native plants within the wastewater lift station site, staging areas, storage areas, piping alignment, etc. for potential salvage and reuse per the City of Phoenix supplement to the MAG Standards. The RLA shall provide recommendations for the following:

- Notice of Intent to Clear Land, written and delivered to the Arizona Department of Agriculture.
- Plant inventory (by species, number, and location) and salvage plans.
- Compliance with Section 710 of the Phoenix Zoning Ordinance, (Hillside Area Development).
- Specifications for site restoration.
- Compliance with restoration or re-vegetation requirements imposed by ADEQ to satisfy 401 certification conditions.

11.6.2 Plantings and Ground Cover

Landscape planting shall be indigenous plant species appropriate for the region. All species shall be selected for ease of maintenance, hardiness, and drought tolerance. Because Phoenix is a desert community, plant selections should serve as an example of aesthetically pleasing, yet reasonable techniques of resource management and water conservation wherever possible. In areas where ground cover is a City requirement, it is required that graded, decomposed, crushed granite be employed. Color and size of materials and plantings shall be carefully selected to emphasize and strengthen the facility’s relationship with the surrounding environment.

The RLA must consider the safety and security of the lift station facility while specifying plant species and locations. Landscaping materials must not aid in gaining access into the lift station. Trees shall not be planted in the proximity of the lift station’s perimeter wall, keeping in mind the mature height of the tree. Only low-growing or insubstantial shrubs may be planted near the lift station wall.

11.6.3 Irrigation System

Irrigation system design criteria shall harmonize with the public image of the client as a responsible resource management organization. As such, irrigation water should not be visibly wasted to evaporation, but rather efficiently and unobtrusively delivered to the point of use through underground piping (i.e. drip system) and operated by a controller system. Refer to the City of Phoenix Supplemental to MAG Standard Specifications and Details for specific provisions for the construction of irrigation systems, including trenching, piping, backflow preventer assemblies, valves, fittings, emitters, controllers and wiring.

SECTION 12 - REFERENCES

1. City of Phoenix Design Standards Manual for Water and Wastewater Systems
2. The Code of the City of Phoenix, Arizona.
3. Sanks, R. L., Tchobanoglous, Bosserman II, B., and Jones, G. (Eds.), “Pumping Station Design”, Second Edition, 1998, Butterworths.
4. Administrative Procedures No. 13 published by the City of Phoenix Engineering and Architectural Services Department.
5. Maricopa County Association of Governments, MAG, Uniform Standard Details for Public Works Construction including the City of Phoenix Supplemental thereto.
6. Maricopa County Association of Governments, MAG, Uniform Standard Specifications for Public Works Construction including the City of Phoenix Supplemental thereto.
7. City of Phoenix, Regulatory Compliance and Excellence Program Wastewater Collection Lift Station and Odor Control Station Assessment and Needs Report, Black & Veatch, September 2007.
8. City of Phoenix, Security Design Guidelines for Remote Facilities, Kimley Horn & Associates, May 2009.