SACRAMENTO REGIONAL COUNTY
SANITATION DISTRICT
SACRAMENTO COUNTY SANITATION DISTRICT ONE
SEWAGE PUMP STATION DESIGN MANUAL

February 2005

Submitted to:

Sacramento Regional County
Sanitation District
10545 Armstrong Avenue, No. 101
Mather, CA 95655

Prepared by:

Nolte Associates, Inc.
1750 Creekside Oaks Drive, Suite 200
Sacramento, CA 95833
(916) 641-1500 • (916) 641-9222 (fax)

Lucy & Company
1614 19th Street
Sacramento, CA 95814
(916) 491-3161 • (916) 491-3160 (fax)

EETS, Inc.
3628 Madison Ave., Suite 21
North Highlands, CA 95660
(916) 339-9691 • (916) 339-9625

SWAT Engineering
3065 Richmond Pkwy., Ste. 115
Richmond, CA 94806
(510) 758-7394 • (510) 758-7396 (fax)

Edited by:

Professional Technical Writing & Consulting
7510 Shoreline Drive
Stockton, CA 95219
(209) 951-3551
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### ABBREVIATIONS

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<th>Full Form</th>
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<tr>
<td>AOR</td>
<td>Acceptable Operating Range</td>
</tr>
<tr>
<td>ASHRAE</td>
<td>American Society of Refrigeration and Air Conditioning Engineers</td>
</tr>
<tr>
<td>AWWA</td>
<td>American Water Works Association</td>
</tr>
<tr>
<td>BEP</td>
<td>Best Efficiency Point</td>
</tr>
<tr>
<td>BWF</td>
<td>Base Wastewater Flow</td>
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<tr>
<td>C/S</td>
<td>Constant Speed</td>
</tr>
<tr>
<td>CalEPA</td>
<td>California Environmental Protection Agency</td>
</tr>
<tr>
<td>CalOSHA</td>
<td>California Occupational Safety and Health Administration</td>
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<tr>
<td>CPM</td>
<td>Central Processing Module</td>
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<tr>
<td>DWF</td>
<td>Dry-Weather Flow</td>
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<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>ESD Unit</td>
<td>Equivalent Single-Family Dwelling Unit</td>
</tr>
<tr>
<td>gpd</td>
<td>Gallons per Day</td>
</tr>
<tr>
<td>gpm</td>
<td>Gallons per Minute</td>
</tr>
<tr>
<td>GWI</td>
<td>Groundwater Infiltration</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating, Ventilation, and Air Conditioning</td>
</tr>
<tr>
<td>I&amp;C</td>
<td>Instrumentation and Controls</td>
</tr>
<tr>
<td>IO</td>
<td>Input/Output</td>
</tr>
<tr>
<td>LWL</td>
<td>Low Water Level</td>
</tr>
<tr>
<td>M&amp;O</td>
<td>Maintenance and Operations</td>
</tr>
<tr>
<td>NPSH</td>
<td>Net Positive Suction Head</td>
</tr>
<tr>
<td>OIP</td>
<td>Operator Interface Panel</td>
</tr>
<tr>
<td>OIT</td>
<td>Operator Interface Terminal</td>
</tr>
<tr>
<td>OSHA</td>
<td>Occupational Safety and Health Administration</td>
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<tr>
<td>P&amp;ID</td>
<td>Process and instrumentation diagram</td>
</tr>
<tr>
<td>PDR</td>
<td>Preliminary Design Report</td>
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<tr>
<td>PF</td>
<td>Peaking Factor</td>
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<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>PM</td>
<td>Preventative Maintenance</td>
</tr>
<tr>
<td>POR</td>
<td>Preferred Operating Range</td>
</tr>
<tr>
<td>PSDM</td>
<td>Pump Station Design Manual</td>
</tr>
<tr>
<td>psf</td>
<td>Pounds per Square Foot</td>
</tr>
<tr>
<td>psi</td>
<td>Pounds per Square Inch</td>
</tr>
<tr>
<td>PWWF</td>
<td>Peak Wet-Weather Flows</td>
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<tr>
<td>RD/I</td>
<td>Rainfall Dependent Inflow and Infiltration</td>
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<td>RTU</td>
<td>Remote Thermal Unit</td>
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<tr>
<td>SCADA</td>
<td>Supervisory Control and Data Acquisition</td>
</tr>
<tr>
<td>TCO</td>
<td>Total Cost of Ownership</td>
</tr>
<tr>
<td>TDH</td>
<td>Total Design Head</td>
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<tr>
<td>V/S, VFD</td>
<td>Variable Frequency Drives</td>
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CHAPTER 1 – BACKGROUND AND PURPOSE

1.0 GENERAL

1.0.1 The Sacramento Regional County Sanitation District (SRCSD) and County Sanitation District 1 (CSD-1) are responsible for designing and constructing new wastewater pump stations in their respective service areas. Previously, there were no overall criteria or standards to ensure consistency among pump station design projects. The SRCSD and CSD-1 developed this Sewage Pump Station Design Manual (PSDM) to provide guidance on the most effective design practices for new pumping stations. This PSDM is intended to:

a. Establish design guidelines for new pump stations in interceptor conveyance and local trunk collection systems.

b. Identify design functions required by a pump station Design Consultant (Consultant).

c. Provide an acceptable level of quality and uniformity in pump station design.

d. Provide consistency and simplicity in Maintenance and Operation (M&O) requirements.

1.0.2 Development of this PSDM was a collaborative process with SRCSD and CSD-1 (District) management, engineering, and M&O staff. Through a series of workshops, brainstorming sessions, and technical reports, design criteria for pump stations were proposed as a function of pump station size and potential risk of overflow. The criteria are summarized in the PSDM along with pertinent information concerning M&O practices, suggested guidelines for public outreach, design document requirements, and anticipated Consultant services.

1.0.3 The District goal is to design and construct a cost-effective pump station that meets the following requirements or objectives:

a. Avoids flooding of the lift station and surrounding areas;

b. Provides a pump capacity and configuration capable of handling all wastewater flow conditions;

c. Ensures reliable, continuous operation;

d. Allows for easy operation and maintenance of installed equipment;

e. Accommodates future capacity requirements;
f. Avoids septic conditions and excessive release of odors in the collection system and at the lift station;

g. Minimizes environmental and neighborhood impacts.

1.1 ACKNOWLEDGEMENTS

1.1.1 Preparation of this PSDM would not have been possible without significant contributions from SRCSD and CSD-1 staff. The input, feedback, and guidance from the following individuals is gratefully acknowledged:

Management:

Mary Snyder
Mike Maggi
Tim Lloyd

Engineering:

Neal Allen
Mostafa Eldin
Ron Baptista
Jay Fenske
Christoph Dobson
John Boehm
Dave Ocenosak
Drew Gilpen

Maintenance and Operations:

Michael Brady
John Chueh
Erin Harper
Charles (Mike) Dixon
Ron Mickelson
Steve Sturch
Dennis Baldwin
Don Rojo
Graham McEntire
John Hough

Communications Management Division:

Bernie Small
Jose Ramirez
Jody Allen
Melenie Spahn

General Services:

Allan Tilja
Tim Anderson
George Madera

Control Systems

Bob Imrisek, Sr.

Other Departments:

Mark Barnreiter
Sue Daly
Jeff Saunders
Phil Allen

1.2 CONSULTANT TEAM

1.2.1 This PSDM was prepared by the following individuals:

Nolte Associates, Inc.:

Dave Richard
Rachid Ait-Lasri
Dianne Rich
Tracie Sakakihara
Mike Pugh
Dr. Robert Sanks

Electrical Engineering and Testing Services:

Michael Bregar
Mitch Larkin
Al d’Heurle

SWAT Engineering:

Fred Fong
Ron Bick
Richard Bradish
Hamdy Osman
Ali Agrama

Lucy & Company:

Melinda Posner
Jeff Chandler
Peter Castles
CHAPTER 2 – APPLICATION OF DESIGN MANUAL

2.0 GENERAL

2.0.1 This Pump Station Design Manual (PSDM) is developed for use by Consultants preparing design documents (reports, plans, specifications, estimates, calculations, and manuals) for wastewater pump stations to be maintained and operated by District staff. District M&O group’s extensive involvement in the preparation of this PSDM has assured that design criteria and desired facility features incorporate long-standing operational preferences, with a focus on minimizing life cycle costs and potential risks. Design criteria in this PSDM are particularly useful in establishing District expectations for small and medium-size pump stations and in expediting project design approvals. Design criteria are included in this PSDM for larger pump stations, but it is recognized that due to the inherent complexity and unique nature of their design, certain deviations from these design guidelines are inevitable. Design criteria will be periodically updated in the future to incorporate any future technical advances involved in the operation and maintenance of various pump stations within the District.

2.1 ORGANIZATION OF MANUAL

2.1.1 The PSDM is organized into a series of chapters detailing District expectations for Consultant services, maintenance and operations group practices and design perspectives for wastewater pump stations, public outreach program guidelines, and recommended design criteria. District standards and guidelines are presented in the following design disciplines: hydraulics, civil, site design, structural, mechanical, HVAC, electrical, instrumentation, and SCADA. To facilitate Consultant use of the electronic version of this PSDM, a series of hyperlinks have been established for key words, graphical representations, and reference documents. In the paper version of the PSDM, hyperlinks are highlighted in blue text (example: Table 6-1).
CHAPTER 3 – DESIGN DOCUMENT REQUIREMENTS AND ANTICIPATED CONSULTANT SERVICES

3.0 GENERAL

3.0.1 Using background information and design criteria presented in this PSDM, the pump station designer (Consultant) can prepare reports and contract documents for subsequent District review and approval. The Consultant may be under contract to a land owner/developer or directly to the District. The role of the Consultant will begin with preliminary design, extend through final design activities, and finish with facility startup and staff training. Specific documents will be prepared by the Consultant during each phase of project implementation. District expectations for these documents and anticipated Consultant services are summarized in this chapter.

3.1 PRELIMINARY DESIGN

3.1.1 During preliminary design, the Consultant will confirm the suitability of the site for pump station construction, evaluate facility alternatives, and confirm station features as a function of capacity and risk. These activities will be accomplished through a geotechnical investigation, site survey, environmental investigation, and preliminary design report. Each is described below.

3.1.2 Geotechnical investigations:

a. Geotechnical investigations in support of pump station design should consist of subsurface explorations, laboratory analyses of soil samples, and engineering evaluations. Borings should be drilled to a minimum of 5 feet below the anticipated wet well floor. A geotechnical report should be prepared summarizing the results of the field activities and providing the following information:

(1) 1997 UBC design information per Section 16

   (a) Seismic zone

   (b) Soil profile type

   (c) Seismic source type

   (d) Closest distance to known seismic source

(2) Foundation recommendations (minimum depth of footing, minimum width of footing, subgrade preparation)

(3) Allowable soil bearing pressure
3.1.3 Survey and mapping:

a. A survey of the proposed site should be undertaken by the Consultant to facilitate subsequent design activities. The survey should confirm site property boundaries and establish horizontal and vertical control for mapping. Vertical control should be tied to Sacramento County benchmarks while horizontal control should be linked to the California Coordinate System. Mapping should incorporate the following guidelines:

1. Site mapping should be prepared at a scale of one inch equals 20 feet. Vertical contours should be provided at 0.5 foot intervals. Spot elevations determined from field surveys should be recorded to the nearest 0.1 foot.

2. Planimetric features should include all surface manifestations such as fences, roads, pavement, sidewalks, power poles, trees, manholes, pull boxes, drainage facilities, and vaults. Utility premarking of visible features is recommended to facilitate identification and mapping of underground utilities.

3.1.4 Environmental investigations:

a. A Phase I Environmental Site Assessment (ESA) is required for each potential pump station site. The purpose of the ESA is to evaluate the possible environmental impacts to soil and/or groundwater that may have resulted from past or current activities at the site. Information generated during the ESA can be used to develop plans to investigate and mitigate potentially hazardous area(s) during construction. Preparation of the ESA should follow the guidelines presented in ASTM E1527, Standard Practices for Environmental Site Assessments, Phase I - Environmental Site Assessment Process and consist of the following activities.

1. Site Reconnaissance - General conditions at the site and adjacent properties should be observed as they relate to possible environmental impairment. During site reconnaissance, on-site and off-site features suspected to be potential
sources of soil and/or groundwater impairment should be photographed. Features identified during site reconnaissance should be documented in field notes and recorded on a site map. Adjacent commercial facilities should be identified by name and address. This information can then be used to obtain public information from regulatory agencies regarding chemical usage at the identified facilities (e.g. hazardous materials management plans, underground storage tank permits).

(2) Historical Review - The objective of the historical review is to evaluate whether past activities may have environmentally affected the site. This review does not include an extensive historical review of surrounding properties, but should focus on the proposed site and immediately adjacent properties.

(3) Review of Regulatory Agency Lists and Files - Regulatory agency files should be searched to obtain information pertaining to environmental investigation on or near the proposed site, the current or former presence of registered underground storage tanks (USTs) that may be located immediately adjacent to the proposed site, and chemical usage at specific facilities identified during the site reconnaissance. Information obtained from the regulatory review should be evaluated to ascertain potential soil or groundwater impacts that could require mitigation prior to construction or require special consideration during construction. Data should also be evaluated by the Consultant to determine the necessity of a Phase II Site Assessment.

3.1.5 Preliminary design report: 

a. The Consultant should prepare a preliminary design report (PDR) which includes a summary of all preliminary design activities including geotechnical investigations, environmental site assessments, and topographic mapping (including delineation of site boundaries). The PDR should include preliminary design drawings illustrating site layout, pump station configuration, equipment orientation, and ancillary facilities. The document should address all design criteria and include a discussion of the following:

(1) Rationale for pump station site selection including a review of potential risk and public acceptance issues

(2) Projected wastewater flows and anticipated phasing

(3) Force main sizing

(4) Projected system head curve, recommended pump selection, and anticipated power requirements

(5) Size classification and risk level of the pump station
(6) Required permits to construct and operate the pump station

(7) Noise impacts and recommended attenuation

(8) Total cost of ownership (life cycle costs) for the selected design alternative

(9) Design elements demonstrating compliance with the District-required features for the stated size and risk level

(10) Elements exceeding District design requirements

(11) Any proposed alternatives to the District design requirements, demonstrating quantitatively how they would provide superior reliability, lower risk, and lower operating and maintenance costs

(12) Subsystem features, functions, and operating characteristics

(13) Selected nominal pump station voltage

(14) One-line diagram and general plan view with preliminary location of major electrical facilities

(15) Operational plan for variable speed pumping (if proposed)

(16) Preliminary process and instrumentation diagram (P&ID) including SCADA I/O

(17) Proposed instrumentation types, manufacturers and control functions

(18) Compliance with instrumentation standardization requirements, with an explanation for any deviation from these criteria

(19) Placement, location, and grouping of instrumentation systems

(20) Backup to critical instrumentation systems affecting flooding and safety

(21) Whether or not intelligent device communication will interface with the SCADA system

(22) Proposed SCADA PLC and OIT hardware and their compliance with defined District standards

b. A draft PDR should be submitted initially for District review and feedback prior to completion of preliminary design. Acceptance of proposed pump station features and confirmation of probable life cycle costs by District staff are prerequisites to
completion of the final PDR and initiation of final design. Following receipt of District comments and feedback, a final PDR should be submitted by the Consultant.

3.2 FINAL DESIGN

3.2.1 Consultant final design services consist of the preparation of plans, specifications, estimates, schedules, and engineering calculations. Construction documents should establish specific contractor and District responsibilities during station procurement and implementation. Recommended responsibilities are described below.

a. Contractor should construct all station improvements including underground, structural, mechanical, electrical, and site components.

b. Contractor should procure and install all mechanical and electrical equipment.

c. Contractor should procure and install instrumentation and controls hardware.

d. Contractor’s Instrumentation and Controls (I&C) sub-vendor should accomplish panel internal wiring.

e. Contractor’s electricians should accomplish field wiring of instrumentation and controls.

f. Contractor should provide all wiring from source devices and instruments through to PLC I/O.

g. Contractor should calibrate and certify instruments to required settings.

h. Contractor should be responsible for energizing control panel and instrument loops and demonstrating all local-manual (non-PLC) control functions to the District.

i. Contractor should assist the District to systematically demonstrate and commission PLC I/O prior to, or concurrent with, the download and testing of the District’s PLC and OIP programming.

j. District will first commission the PLC and OIP to prove proper local indication and automatic control.

k. District will separately commission the remote SCADA controls after completion of local control work.

3.2.2 Plans:

a. Pump station designs are represented by the engineered plans that are published for public bidding or negotiated with a pre-selected contractor (developer financed pump
station). Plans are organized typically by design discipline and should include General, Civil, Landscaping, Structural, Mechanical, HVAC, Plumbing, and Electrical drawings. In general, drawing content and presentation is determined by the Consultant. However, the design documents related to instrumentation and controls must be prepared in a standard format for optimal ease of use by the District’s M&O staff. Specifically, documents to be produced by the Consultant to District standards should include:

1. P&IDs
2. Instrument loop diagrams showing all conductors and terminations of analog signal wiring.
3. PLC I/O connection diagrams
4. Instrument list (spreadsheet) with tag, manufacturer, model, and desired calibration data.

b. Documents related to I&C to be produced by the District (or by consultant under separate contract) will include:

1. SCADA IO list database file
2. Datalogging spreadsheet designating PLC register groups and address assignments
3. Control logic manual

c. Recommended design drawings for a typical pump station to be produced by the Consultant are listed below. Plans should be submitted for District review of the 50 percent, 90 percent, and 100 percent completion stages.

**General:**

G1 - Title Sheet, Index of Drawings

G2 - Vicinity Map, Location Map

G3 - Abbreviations, Standard Symbols

G4 - Basis of Bearing, Benchmark Information, Site Boundary/Property Line

**Civil:**

C1 - Site Plan
C2 - Grading - Paving Plan
C3 - Exterior Piping Plan
C4 - Site Development Details
C5 - Site Piping Details

Landscaping:
L1 - Planting Plan
L2 - Irrigation System Plan
L3 - Planting and Staking Details
L4 - Irrigation System Details

Structural:
S1 - Foundation Plan
S2 - Wet Well/Dry Well Sections
S3 - Top Deck Plan
S4 - Building Elevations
S5 - Building Sections
S6 - Roof Framing Plan
S7 - Roofing Details

Mechanical:
M1 - Pumping Equipment Plan
M2 - Equipment Sections
M3 - Ancillary Facilities Plan
M4 - Odor Control System Plan and Details
M5 - Equipment Schedules

HVAC:

H1 - Ventilation Plan
H2 - Ventilation System Details
H3 - Fan and Louver Schedules

Plumbing:

P1 - Plumbing Plan
P2 - Plumbing Schedules

Electrical:

E1 - Electrical Site Plan
E2 - One-Line Diagram
E3 - Main Switchboard/Motor Control Center Details
E4 - Control Schematics
E5 - Schedules (Panelboard/Lighting/Cable-Conduit/I/O Listing/Instrumentation List)
E6 - Logic Diagrams
E7 - P&IDs
E8 - Instrumentation Loop Diagrams
E9 - Elevation Details
E10 - Interconnection Diagrams
E11 - Wiring Diagram

3.2.3 Specifications:

a. Pump station project specifications should include bidding and contract requirements, District special provisions, documentation requirements, and technical specifications.
Bidding and contract requirements, general conditions, and special provisions may vary for developer financed pump station projects based on the procurement strategy. Technical specifications should be prepared in Construction Specification Institute (CSI format). Suggested specification sections are summarized below.

**Bidding and Contract Requirements:**

- Notice to Contractors
- Bid Form
- Bid Schedule
- Attachment A – Statement of Experience of Bidder
- Attachment B – Designation of Subcontractors
- Attachment C – Statement of Experience of Subcontractor
- Attachment D – Equipment Supplier Listing
- Attachment E – Performance Bond
- Attachment F – Payment Bond

**District Special Provisions (SP):**

- SP-01 Standard Specifications
- SP-02 State Specifications and State Standard Plans
- SP-03 Scope and Location of Work
- SP-04 Differing Site Conditions
- SP-05 Existing Conditions
- SP-06 Time of Completion
- SP-07 Liquidated Damages for Delay
- SP-08 Construction Sequencing and Constraints
- SP-09 Contractor’s Use of Premises
- SP-10 Storage and Disposal of Construction Materials
- SP-11 Contractor Site Office and Facilities
- SP-12 Engineer’s Office Facilities
- SP-13 Relationship of Entities Associated with the Project
- SP-14 Permits and Licenses
- SP-15 Erosion and Sediment Control
SP-16 Coordination with Utilities and Property Owners
SP-17 CPM Construction Schedule
SP-18 Photographs
SP-19 Dust Control and Site Cleanliness
SP-20 Public Safety and Traffic Control
SP-21 Restoration of Existing Improvements
SP-22 Construction Progress Meetings
SP-23 Measurement and Payment
SP-24 Contractor’s Submittals
SP-25 Records Drawings
SP-26 Reference Forms
SP-27 Escrow Bid Documents
SP-28 Insurance Provisions
SP-29 Project Partnering Relationship
SP-30 Surveying
SP-31 Protection of Workmen
SP-32 Quality Control

Contractor Documentation/Submittal Requirements

- As-Built Drawings
- Equipment Operation and Maintenance Manuals
- Training and Troubleshooting Materials

Division 1 – General Requirements

- Section 01071 Standard References
- Section 01605 Shipment, Protection and Storage
- Section 01660 Equipment and System Performance and Operational Testing
- Section 01662 Commissioning
- Section 01664 Training
- Section 01730 Operating and Maintenance Information
- Section 01800 Environmental Conditions
Division 2 – Site Work

Section 02100 Site Preparation
Section 02160 Excavation Support Systems
Section 02200 Excavation, Backfilling, and Compaction for Utilities
Section 02210 Excavation, Backfilling, and Compaction for Structures
Section 02510 Asphalt Concrete Paving
Section 02610 Chain Link Fencing
Section 02800 Irrigation Systems
Section 02900 Landscaping

Division 3 – Concrete

Section 03100 Concrete Formwork
Section 03200 Concrete Reinforcement
Section 03300 Cast-in-Place Concrete
Section 03600 Grout

Division 4 – Masonry

Section 04200 Reinforced Concrete Masonry Unit

Division 5 – Metals

Section 05031 Hot-Dip Zinc Coating
Section 05100 Structural and Miscellaneous Metals
Section 05501 Anchor Bolts and Power Actuated Fasteners

Division 6 – Woods and Plastics

Section 06100 Miscellaneous Carpentry

Division 7 – Moisture Protection

Section 07200 Building Insulation
Section 07511 Built-Up Asphalt Bituminous Roofing
Section 07620 Sheet Metal Flashing and Trim
Division 8 – Doors and Windows

Section 08110 Steel Doors and Frames
Section 08310 Aluminum Floor Hatch
Section 08710 Finish Hardware
Section 08800 Glazing

Division 9 – Finishes

Section 09800 Coating Systems

Division 11 – Equipment

Section 11000 General Requirements for Equipment
Section 11002 Equipment Mounting
Section 11015 Noise Requirements and Control
Section 11020 General Vibration Requirements
Section 11140 Wastewater Pumps
Section 11200 Fabricated Gates
Section 11300 Odor Control Systems

Division 13 – Special Construction

Section 13001 Fuel Storage System

Division 14 - Conveying Systems

Section 14600 Cranes and Hoists

Division 15 – Mechanical

Section 15010 Mechanical Requirements for HVAC Equipment
Section 15050 Materials and Methods for HVAC Equipment
Section 15060 Piping Systems
Section 15090 Expansion Joints
Section 15096 Pipe Hangers and Supports
Section 15097 Seismic Restraints for Piping
Section 15101 Knife Gate Valves
Section 15110 Eccentric Plug Valves
Section 15111 Sluice Gate Hydraulic Operator
Section 15118 Swing Check Valves – Controlled Closing Type
Section 15185 Valve and Gate Operators and Operator Appurtenances
Section 15250 Insulation
Section 15400 Plumbing
Section 15500 Heating, Ventilating, and Air Conditioning (HVAC)
Section 15990 Testing, Adjusting and Balancing

Division 16 – Electrical

Section 16010 Electrical General Requirements
Section 16030 Coordination Study
Section 16110 Conduit, Raceways, Fittings, and Supports
Section 16120 Wire and Cable-600 Volt and Below
Section 16121 Medium Voltage Cable
Section 16130 Junction or Device Boxes
Section 16140 Wiring Devices
Section 16150 Induction Motors
Section 16200 Lighting Fixtures
Section 16320 Medium Voltage Padmount Transformers
Section 16346 Main Service Medium-Voltage Switchgear
Section 16400 Electrical Service and Distribution Equipment
Section 16426 Electrical Distribution Switchboards
Section 16452 Grounding System
Section 16482 Motor Control Centers
Section 16485 Variable Frequency Drive Systems
Section 16496 Automatic Transfer Switch
Section 16500 Engine Generator Systems
Section 16600 Control Sensor Switches and Auxiliaries
3.2.4 Opinions of probable construction cost:

a. Opinions of probable construction cost serve multiple purposes. These purposes include validating initial assumptions regarding life cycle costs, confirming project budgets, providing a better understanding of the value of facility features, and allowing a subsequent comparison/validation of contractor bid results. The summary of probable construction costs should be broken down in sufficient detail to identify key facility components and their relationship to the overall project cost. The summary should also mirror, if appropriate, the Bid Schedule in the contract documents to facilitate review of bid results. Opinions of probable construction cost should incorporate contingencies for unforeseen conditions and increase to the mid-point of construction. Construction cost summaries should be submitted periodically during the design process, specifically at the 50 and 100 percent completion levels. The 50 percent construction cost summary should be compared to the preliminary construction budget presented in the PDR and any significant differences should be highlighted for District review. Similarly, cost summaries changes between the 50 percent and 100 percent submittals should be tracked and documented for potential District action. Each construction cost summary submitted by the Consultant should include a discussion of the basis of specific unit costs, budget quotations from potential equipment vendors, and other site specific assumptions.

3.2.5 Preliminary construction schedules:

a. A preliminary construction schedule, to determine the duration of the projected construction contract, should be prepared by the Consultant for District review and comment. The preliminary construction schedule should include all major construction activities along with any supporting District tasks, such as PLC and SCADA system programming. As part of schedule development, the Consultant should verify the following with each manufacturer: shop drawing, fabrication, and delivery duration for critical mechanical and electrical equipment. If appropriate, a specific construction sequence should be identified in the preliminary schedule to highlight any constraints warranting the Contractor’s attention. Preliminary construction schedule information should be included in the project contract specifications in SP-06, Time of Completion, and SP-08, Construction Sequencing and Constraints. Substantial completion in the preliminary construction schedule should coincide with the completion of SCADA testing.
3.2.6 Engineering Calculations

   a. The Consultant should prepare engineering calculations to confirm equipment sizing, hydraulic requirements, building parameters, and subsystem characteristics. Calculations will usually include the following:

   (1) Projected wastewater flows
   (2) Wet well sizing calculations
   (3) Emergency storage calculations
   (4) System head calculations
   (5) Pump total dynamic head calculations
   (6) Electrical load calculations
   (7) Voltage drop calculations
   (8) Lighting calculations
   (9) Heat balance calculations

3.3 POST DESIGN

3.3.1 Near the end of final design activities, the Consultant should begin to play a key role in insuring the successful startup of the pump station, as well as the integration of the station into the overall District system. The Consultant should act on behalf of the M&O staff to ensure that all relevant construction contract expectations are either met, or brought to the attention of stakeholders for subsequent resolution. Specific recommended Consultant activities are described below.

3.3.2 Documentation:

   a. The Consultant should provide to the District’s M&O staff documents related to the design, construction and startup of the new pump station including as-built plans and conformed specifications. This set of documents should include the following:

      (1) Engineering Information: All documents shall be submitted in electronic and paper form. The electronic copies should be deposited in an eRoom designated by District staff, while the paper copies should be delivered to assigned District project personnel.

      (a) Drawings:

         i. All drawings shall be provided in AutoCAD consistent with District standards, with appropriate 3-D renderings to facilitate M&O staff
training and familiarization. Drawings should be updated to reflect as-built conditions.

ii. A P&ID depicting how all the major components work together should be provided. The P&ID should include all process flow rates and control action specifications.

(b) Description of System Operations:

i. The Consultant should provide a manual that thoroughly describes how the system operates. This manual should include how wastewater flows into the station, how the flow is measured, how flow passes through the station, and how all ancillary equipment works to support the station. If station phasing is anticipated, a discussion of the timing of pump installation versus service area development should be included.

ii. Complete descriptions for each component of major equipment, including design capacities and function within the system, should be provided.

iii. A complete description of the instrumentation system, including how it works to internally control the operations of the station, and how it interacts with the overall sewer system should be provided.

iv. A description of all the specialty systems, such as vibration monitoring, etc., should be provided.

v. A description of all health and safety related items should be provided.

vi. Descriptions of all environmental control items, including odor and noise abatement, overflow protection, etc., should be provided.

(c) Maintenance of System: The Consultant should list all maintenance requirements for the major equipment items. All reference documentation from individual vendors should also be included for easy access.

3.3.3 Operations documents:

a. Using standards to be established by District M&O staff, including format and content specifications, the Consultant should provide the following:

(1) A full set of startup, shutdown and normal operations procedures for the entire system.
(2) Procedures for startup, shutdown, and normal operations for independent equipment items, such as generators, pumps, odor abatement equipment, noise abatement equipment, chemical storage and injection, etc.

(3) Any maintenance procedures deemed necessary to ensure adequate care of the equipment.

b. Initial District requirements for maintenance and operations information to be provided by the Contractor are presented below.

(1) For use in subsequent maintenance and operations the Contractor should furnish, unless otherwise provided for in the Special Provisions, one (1) original and five (5) copies, all bound and indexed, of the maintenance and operation information, including all the highest level of factory maintenance manuals that are available to factory representatives with a three-year subscription to newsletters and updates supplied by the manufacturer covering all equipment and systems included in the contract. Documentation should be provided in hard copy form and where available in native format such as Word, Excel, AutoCAD R14 (min.) or *.pdf. The submittal should include at a minimum:

(a) Drawings:
   i. As-Builts - Electrical, Mechanical, Site
   ii. Detail drawings of structures on the site
   iii. Dimensions
   iv. Site layout
   v. Underground lines including: existing underground lines (plumbing, electrical gas, etc.); incoming and outgoing underground lines (plumbing, electrical, gas, etc.); pre-existing underground lines (plumbing, electrical, gas, etc.); underground conduit (electrical wiring, rigid PVC)
   vi. Wiring diagrams for equipment located on-site (generator, RTU, hoist, etc.)
   vii. Wiring diagrams for structures
   viii. Wiring diagrams of systems

(b) Parts list

(c) Illustrations
(d) Internal wiring diagrams and distribution schematics and layout drawings
(e) Manufacturer’s recommended spare parts lists
(f) Name, address, and phone number of nearest parts and service agency
(g) Maintenance and service instructions
(h) Operations instructions
(i) Software including annotated source lists and programs
(j) Calibration instructions
(k) Calibration reports
(l) Diagnostic manuals

(2) The following guidelines are provided for determining whether or not a part should have documentation:

(a) Systems such as trash racks, motor control centers, or chemical injectors
(b) Components that require programming or extensive set-up such as PanelMate Interfaces and radios
(c) Components that require routine calibration such as Rosemount pressure transducers
(d) Components that have parts that can be ordered individually for repairs such as pumps or motor control centers
(e) Components that require routine or annual maintenance
(f) Components that have performance curves/specifications such as motors and pumps
(g) Components that are under warranty

3.3.4 Training documents:

a. Using format and content specifications provided by District M&O staff, the Consultant should provide the following:
(1) A set of training manuals or training aids to be used in training M&O personnel. This documentation should be based on engineering documents described earlier, but presented at a more condensed level. The language and style should be suitable for the intended audience (non-technical personnel and mechanics).

(2) When eLearning modules are to be prepared, the Consultant should coordinate with the District IT group to ensure adequate design features are included to allow sending the information over the Intranet.

3.3.5 Consultant assistance in system start-up:

a. Consultant assistance is anticipated in the following areas:

(1) Startup Plan for the Pump Station:

(a) Assist District M&O staff to develop a startup sequence and construct a startup schedule that is agreeable to all decision makers.

(b) Examine the proposed testing plans submitted by the Contractor for all major equipment items, including pumps, large valves with actuators, generators, switching gear, MCC, instrument and control systems, etc.

(c) Witness and approve testing in cooperation with District M&O staff.

(d) Work with the Contractor and vendors to resolve any problems during testing and ensure standards are met.

(e) Document testing and organize vendor manuals according to project and/or M&O standards.

(2) System-Wide Integration of Pump Station: The integration of the new pump station with the rest of the sewer collection system is of paramount importance. The Consultant should:

(a) Assist District M&O staff to sequence the startup phases, and to ensure that disruptions to the existing system are kept to an absolute minimum.

(b) Ensure integration with the central monitoring station is complete and well understood by all parties.

(c) Suggest resolutions for any weakness in system integration.

(d) Document the weaknesses for future resolution by the District.
CHAPTER 4 – MAINTENANCE AND OPERATION GROUP PRACTICES AND DESIGN PERSPECTIVES

4.0 GENERAL

4.0.1 Maintenance and operation of all pumping stations within the SCRSD and CSD-1 are operated and maintained by the M&O group of the Water Quality Division. M&O also supports a number of other County departments or agencies, including the County Department of Water Resources (storm drains and potable water), the International Airport, the Park and Recreation Department, the Emergency Power Division for the Transportation Department, and Facilities Management. The M&O group is the actual owner of the sewer collection system, and as such, is very interested in the design of new pumping stations and the renovation of existing facilities. For reference, these pumping stations have been constructed throughout the more than sixty year history of the District. There are many aging facilities remaining and relatively new pumping plants. Older stations are renovated regularly. Natomas and Cordova are the latest stations to be renovated.

4.0.2 Smaller pumping stations are designed and constructed by private developers and then turned over to the District for operations and maintenance. Over the years, a lack of standardization in these smaller stations has resulted in significant problems during the engineering/construction phases, as well as in day-to-day operations. Use of this PSDM by District consultants or engineers retained by private developers is intended to lessen these issues and to streamline later M&O requirements. To understand the rationale for desired pump station features and design criteria, familiarity with current M&O group practices and design perspectives is useful. These topics are addressed in this chapter.

4.1 BACKGROUND

4.1.1 Overview of Pump Station Operations:

a. The pumping stations operate in un-manned automatic mode. Pumps turn on and off based on levels in the sumps that are controlled by an on-site Programmable Logic Controller (PLC). All pumping stations within the collection system are monitored by a SCADA system which transmits data (through radio) into a central control station accessible at a number of locations. This system allows conditions of the stations to be monitored and the central control station can switch to control mode when needed, to directly operate an equipment item. Control and SCADA systems for new pump stations must be compatible with, and communicate effectively with, the central control station to achieve this needed capability.

b. The central control station is only staffed during normal working hours. Real time control of the entire system is passed over to the Sacramento Regional Wastewater Treatment Plant (SRWTP) during off-hours. These personnel are responsible for
calling M&O technicians when off-hour maintenance needs arise. Due to the District size, call-out of technicians during off-hours may lead to a two hour delay before M&O staff can reach a problem location. Once on-site, another two hours may be required to troubleshoot and resolve problems, particularly involving electrical and instrumentation issues. For these reasons, emergency storage and/or automatically-activated redundant equipment are critical concerns for the M&O group.

4.1.2 M&O Practices:

a. To ensure smooth operations of the pump stations, about twenty technicians in supervisor led teams operate out of two corporation yards, serving the North and the South Areas, respectively. All technicians are day shift/weekday workers, except for a crew of technicians on call during off-hours to respond to problems. These teams visit the stations on a scheduled basis for monthly preventative maintenance (PM) work and regular visits to clean out accumulated grease. They also respond to unexpected breakdowns and other problems as they arise. During PM, the technicians follow a written routine to proactively maintain all equipment needing service. Simple activities are accomplished on location, while complex work (pulling large bearings, replacement of large and complicated parts, etc.) is performed in the respective yard’s shops. Pump stations are not inspected on a daily basis, therefore, equipment with high maintenance requirements is not favored by M&O staff.

b. Instrument repair is accomplished by the Building Trade Division within the M&O Department. Electrical services are furnished by electricians from the County General Services Division. This division of labor makes standardized electrical power and instrumentation systems mandatory.

4.1.3 Yard Operations:

a. The two corporation yards include work shops that support routine machine disassembly and reassembly for smaller items. The work shops also support bearing and impeller work required when small pumps are overhauled. Major overhauls and machining is accomplished off site, by private contractors. The two yards staff approximately 60 personnel. The yards have a full complement of mobile equipment, including pipeline repair trucks, sewer cleaning trucks, temporary pumps and power generators, and all necessary support units to operate a large municipal sewer system. Available temporary pumps and portable emergency generators provide the ability to connect piping and power on an emergency basis at individual pump stations - a critical advantage.
4.2 M&O DESIGN PERSPECTIVES

4.2.1 Key M&O design perspectives include the following:

a. The proposed pump station should have the lowest total cost of ownership (TCO) for the District. Cost of ownership should consider the life cycle cost of the pump station including amortized capital costs and long-term maintenance costs.

b. To facilitate maintenance and staff training the Consultant should use standard design templates for small pump stations rather than customized features.

c. For medium and large pump stations, as possible, duplicate previously-proven design features to minimize new training requirements.

d. Follow good ergonomic and human factor design principles to provide easier maintenance and operations.

4.2.2 Additional design considerations are discussed below:

a. Total Cost of Ownership (TCO): The District is in the early stages of developing a strategy for TCO minimization. For instance, the workflow needed to capture field experiences and cost data for major equipment units is being collected to quantify District maintenance cost over time. As part of the preliminary design, the Consultant should request input from M&O staff regarding maintenance costs and use the information in subsequent TCO analyses.

(1) In terms of minimizing the TCO, Consultants should be practical in their design considerations. For example, new facility designs may incorporate superior technology that are lower in engineering and construction costs and have systems simpler to maintain and troubleshoot. However, if the new facility is incorporated into the existing system in a less than optimal manner, subsequent inefficiencies and unexpected training costs will increase the TCO.

(2) Suggested Consultant guidelines to minimize the TCO include:

   (a) Keep the design as simple as possible – sufficient to meet design based on standard features and prevailing District preferences. M&O places great emphasis on implementing demonstrated designs because they have worked effectively. New designs can create significant “hidden” costs when the new designs are integrated into the system. Hidden costs include initial training of technicians, stocking of spare parts, research into unique problems created by the new design, particularly when equipment is inoperative, and maintaining a large collection of equipment maintenance vendor information.
(b) Designs should balance the cost of construction and the post-construction operating and maintenance costs. Post-construction costs include the training of personnel, startup, continuous maintenance, etc. If a potential design may save significant up-front costs but result in excessive upkeep, it should not be pursued by the Consultant. This assessment should be undertaken by the Consultant during preliminary design as part of the total cost of ownership analysis.

(c) For small pump stations, the District desires a standardized design for typical applications. Customization of small pump stations should only be provided in special situations. For larger stations, Consultants should reproduce sections of the overall designs whenever possible.

(d) Pump stations should be designed for a minimum of fifty years of service life.

b. Spare Parts: The District has a growing number of hardware units to manage. Inventory of spare parts to meet daily maintenance needs is a major task. Consultants should try to minimize new types of hardware requirements. This will decrease the need to stock new spare parts. It is District policy that a spare parts cabinet be included at each station, particularly at large pumping stations.

c. Minimize potential environmental impacts: Over the years, sewer spills into environmentally sensitive areas have occurred within the District jurisdiction. Each incident not only results in negative publicity, but also in a large monetary loss. Consultants should be careful to minimize the possibility of large-scale sewer spillage by including sufficient reliability features and storage considerations.

d. Human factors: Engineering designs should conform to standards established in the industry for the protection of workers. Designs should minimize potential human mistakes that can cause events leading to environmental, health, safety or equipment damage. The following general design system requirements should be included:

1. Provide sufficient equipment clearance to protect personnel who will be working in the area.

2. Provide sufficient access so that operation and maintenance activities can be accomplished without the need for extraordinary tools or equipment.

3. Safety equipment (eye wash stations, etc.) must be placed close to potential hazard areas for immediate access if an accident and/or spill should occur.
CHAPTER 5 - PUBLIC OUTREACH PROGRAM GUIDELINES

5.0 GENERAL

5.0.1 The District is committed to facilitating an open public process regarding its programs and services in all of their projects and operations. This is accomplished through frequent and ongoing communication with affected residents, businesses, stakeholders and the general public. Although developer-driven projects may have less public impacts, the issues and concepts discussed here should also be considered for developer-constructed pump stations. For reference, developer-constructed pump stations are typically less than 1 million gallon per day in capacity and serve a limited, local area.

This chapter discusses public outreach issues most frequently encountered during pump station projects. A major goal of outreach efforts is to identify proven, successful approaches and solutions in gaining public support for projects. This chapter has been divided into two sections: design and construction; the primary emphasis is on the design phase. Each section includes a discussion of key issues followed by recommendations for effective outreach to be followed by the Consultant.

5.1 ROLE AND VALUE OF PUBLIC OUTREACH

5.1.1 Public outreach can be a critical component of major infrastructure projects. The public’s renewed calls for open and responsible government indicates future public outreach will be very important. Successful public outreach serves several important purposes. Outreach through public input helps promote support for costly capital projects, helps demonstrate the role of asset management by the District, helps alleviate negative public pressure on elected officials, and helps improve ratepayers’ perception of utility agencies, the media and governing boards.

When properly used, public outreach can serve as a vital tool in gaining public support and obtaining useful public input. Gathering information from the public and stakeholders who are very aware of local conditions - political, environmental or otherwise - can help the Consultant avoid potential pitfalls.

5.1.2 In conducting a successful public outreach program, the following points should be considered by the Consultant:

a. Honesty is the most important principle to maintain throughout the public outreach process with the public and stakeholders. An enlightened public will see through smokescreens or attempts to excessively sugarcoat the truth or hostile issues.
b. Even very small organized groups can lend their support to bring a project to fruition. It is vital to keep members of the public informed and allow them to provide input early and often throughout the process.

c. Effective public outreach at consistent intervals, provides frequent and open communication with the public.

d. Members of the public often just want the opportunity to be heard. If a mutually respectful and trusting relationship can be built between the Consultant and the public, it may serve to defuse public opposition to the project. Allowing public input can help turn potential opponents into ambassadors for the final project.

5.2 DESIGN PHASE

5.2.1 Public outreach typically begins with the design phase. Design is often the Consultant’s first encounter with the general public. It is important during the design phase for the Consultant to set a precedent for later phases and get the message out to the public early and often. By implementing outreach plans that include frequent opportunities for public input in the design phase, the Consultant can foster early public acceptance of the project. This can hasten the design process and also make life easier later for construction and M&O personnel.

5.2.2 Key design issues for this manual, which should be addressed by the Consultant, were identified through interviews conducted with design engineers who either work directly for the District or have worked as consultants on District or non-district pump station projects. Project outreach summaries and other District reports were also reviewed. Based on this data base, the following key design issues were identified:

a. Siting
b. Aesthetics
c. Noise
d. Odor
e. Emergency
f. Facility access
g. Property impacts

5.2.3 A discussion of key design issues to be addressed in the Consultant’s public outreach program is presented below.
a. Siting: Siting is perhaps the most important issue that affects the public. Because the facility will become a permanent landmark where it is built, it is important to weigh public input along with District siting requirements when deciding upon a preferred location for a new pump station. This will help identify any public opposition to potential facility sites.

Most people will not want a pump station in their neighborhoods. This should be balanced versus sites that may create risk for subsequent environmental impacts (overflows to receiving waters). Before design significantly progresses, the Consultant should conduct outreach early to determine the most acceptable sites considering this balance. If too much time and money are invested in designing a preferred alternative before involving the public, the risk of failing to gain public acceptance increases.

It is recommended that the Consultant consider an inclusive set of options before providing the public with information on site alternatives. A small number of alternatives should be presented to the public, each being feasible to build from both an engineering and economic standpoint. The potential risk of overflow should be considered in any assessment of alternative sites. Offering only feasible alternatives to the public will help the Consultant avoid options that do not meet fundamental siting criteria.

It is crucial for the Consultant to anticipate how the public will respond to the acquiring of each specific parcel of land. Although the Consultant may have a preferred alternative, the Consultant must be prepared to select a different site if there is significant public opposition.

When considering alternatives, the public generally prefers that pump stations be built on low-cost land with little development potential. Potential environmental risk should also be considered. The Consultant can explain that the pump station facility is much preferable to other development that might eventually occur on the selected property. The Consultant should meet early and frequently with property owners to negotiate right-of-way and easements.

b. Aesthetics: After siting, facility appearance is probably the next most important public concern. Property owners or tenants who take pride in their homes or businesses, often with significant financial investment, may have concerns that a pump station facility will be an eyesore in their community. Any perceived threat to property values will likely be met with opposition.

Facilities should be designed with architecture that blends into the local surroundings to accommodate public concerns about aesthetics. The public also prefers well maintained, landscaped facilities. Strategic placement of landscape features such as shrubbery and trees can help soften the facility’s industrial features, but for security reasons, landscaping should not completely obscure the facility.
In good faith and recognizing the District commitment to asset management, the Consultant should work with stakeholders from the beginning to develop a pump station that conforms to their needs. Cost-effectiveness should not be sacrificed exclusively to obtain public support, but a balanced, reasonable approach should be undertaken by the Consultant. This practice is particularly important in residential areas. Commercial and industrial facilities usually do not typically require the same aesthetic requirements.

As an example, the District originally designed its Madison Avenue pump station to be housed in a box-type enclosure. After listening to input from the owner of the neighboring apartment complex, the project team changed the design to feature a wood-paneled building that resembles the adjacent apartment building garages. This flexible response satisfied the property owner and probably resulted in increased cooperation during later right-of-way negotiations.

c. Noise: Noise emanating from pump stations is a concern voiced primarily by those in residential areas. During design, the public wants to hear what measures will be taken to mitigate noise. In the past, public concern has been voiced regarding noise related to the facility’s operation and maintenance. Residents are particularly sensitive to noise during the night and early morning hours.

While facility operation typically generates low noise, emergency generators and vehicle backup alarms are more noticeable. County code(s) regarding noise limitations may not always be sufficient for those living near pump station facilities. Facility accessways should be designed to allow vehicles to get in and out without excessive reverse maneuvers. M&O crews have heard many complaints from residents about noise from vehicles backing out of facilities, especially at night.

Input from the public, as well as M&O staff who typically handles complaints, will help the Consultant design adequate noise mitigation measures. Addressing noise issues in design will lead to fewer complaints from the public during operation. Once the pump station is operating, noise reduction measures become much more costly to implement.

d. Odor: The public naturally assumes that undesirable odor is a part of any sewer facility. Because of this, it is important for the Consultant to explain during outreach how odor will be controlled. The safety of odor control techniques and chemicals used in the process should be emphasized. Concern often decreases when the public is educated about the infrequency of odor problems and effective measures that are taken to manage odor.

As with noise mitigation, proactive design to mitigate odor will help prevent public complaints during operation. Including M&O staff and public input during the design phase will contribute to long-term solutions for odor. The Consultant should visit
with property owners in the immediate area of the proposed facility to identify any particular sensitivity.

e. Emergency: The Consultant should develop an appropriate emergency response plan that addresses the steps taken to mitigate any spill. This plan should be shared with the public to reassure concerned individuals that the District has carefully thought out and planned for emergencies.

f. Facility Access: Facility access and the effect on traffic flow is another public concern. The public usually wants to know about large truck traffic, potential traffic delays and controls, and any other potential disruption to normal residential and business activities. For example, during daytime maintenance District vehicles may cause traffic problems while backing out of facilities that do not have adequate space to turn around. As mentioned earlier, vehicles backing out of facilities during late-night hours have caused resident noise complaints.

Unless site constraints prohibit, pump station facilities should be designed with horseshoe-shaped driveways or driveways large enough to allow maintenance vehicles to turn around and not be forced to back into or out of the facility. When these design features are incorporated, they should be shared with the public during the design phase outreach to show the District’s commitment to minimize negative community impacts.

g. Property Impacts: When a pump station is initially proposed, people will want to know what the direct impacts may be to their property. Basic concerns are whether property will be encroached on and if property values will be affected by the presence of the facility. During public outreach, right-of-way and easement issues should be referred to District real estate staff, as necessary.

5.2.4 Key Points to Address Primary Public Concerns: For successful public outreach, the Consultant should develop a consistent set of key points to address positive attributes/benefits and concerns for each pump station. To facilitate consistent, clear communication between the District and the public, the following key points should be followed as response guidelines to public inquiries.

a. Siting: Siting is the first and most important step in a pump station design project (see Chapter Six for recommended criteria). The District makes every reasonable effort to include public input and accommodate public opinion in determining a pump station site.

Whenever possible (and operational requirements allow), the District develops pump stations on low-visibility and low-value lands to minimize negative impact on the surrounding community along with potential risk of overflow.
Developers defer to the District to identify the minimum required site size. The District considers the following in determining site requirements: equipment access, parking, vehicle turn-around requirements, anticipated local traffic, and safety issues.

b. Aesthetics: The District holds its responsibility to serve the public interest as its top priority. The District seeks to incorporate public input in the architectural and landscaping design of its pump station facilities, in an effort to construct a facility that is cost-effective yet does not detract from the local surroundings.

To contribute positively to the community and to discourage loitering and vandalism at the pump station, the District consults with public safety officials to ensure that proper safety measures are incorporated into facility design.

c. Noise: The District takes seriously the public’s concerns about noise impacts and strives to decrease noise from regular facility maintenance and operations and from emergency alarms and vehicles. When possible, noisy operations are conducted during daytime hours at times with the fewest impacts on the fewest number of people.

d. Odor: While pump stations and industrial operations emit some odor, the District goes above and beyond industry standards to decrease odor through environmentally protective measures.

e. Emergency: Emergency events, such as a sewer overflow or spill, are rare due to the extensive technology that is built into every pump station facility. This technology provides backup systems and alarms that alert District crews when intervention is necessary. In the rare event of a spill, emergency crews and public safety officials will respond to the scene immediately to decrease any harm that may be caused to human health and the environment.

f. Facility Access: The District considers proximity to major roadways, effects on traffic and other potential disruptions of normal residential and business operations in determining the location of and access to its facilities. Each facility is designed with a long driveway that is set back from the roadway and allows for vehicles to enter and exit the facility without having to back up into traffic. This design avoids traffic disruption and community nuisance caused by vehicle alarms that sound when workers drive in reverse.

g. Property Impacts: The District takes measures to minimize negative impacts to property values through selection of a less conspicuous site, architectural and landscaping design that blends in with the local community, and noise and odor mitigation of its pump stations.

5.2.5 Classifying Pump Stations and Corresponding Public Outreach Efforts: In any public outreach program, the Consultant should consider a number of factors that might
contribute to the level of outreach needed. There is no scientific formula for determining when a design project needs to implement extensive public outreach. The following factors should be considered when gauging outreach needs at the onset of any project.

a. Size of pump station
b. How critical the pump station is to the overall sewer system (both from operations and timeline perspectives)
c. Demographic makeup of community (residential development density, housing age)
d. Political forces in community surrounding the potential pump station
e. History of previous projects in the area
f. Number of other improvement projects in the area
g. Number of people impacted by the project
h. Board members’ and other policy makers’ sentiment toward the community’s participatory role in decision-making

5.2.6 The Consultant should identify future pump station design projects as having low, medium or high public sensitivity, and apply the suggestions provided in this section. This determination should largely be based on historical District experience in the local area. If previous pump station projects have created little public interest or comment, then a future similar project will likely have low public sensitivity. Conversely, if earlier pump station projects required extensive public outreach, then a high public sensitivity should be assumed regardless of pump station size, siting, or features. When in doubt, greater public sensitivity should be assumed for outreach purposes rather than less.

Suggestions for outreach are presented below. Suggestions are listed first and separated into low, medium or high public sensitivity projects. Public outreach by developers with prospective homeowners may be appropriate to assure full disclosure of potential impacts from adjacent pump station facilities. For reference, low, medium, and high public sensitivity will likely vary based on the size of the pump station, the proximity of the site to residents, and the potential risk of overflow.

a. Suggestions for Low Public Sensitivity: Identify the key stakeholders, residents and property owners in the immediate area adjacent to the design site and get contact information to communicate with them. Develop and distribute a written notice on letterhead to inform stakeholders, residents and property owners of the project’s need, schedule and any associated impacts. Provide advance notice prior to any surveying or other activity that may cause concern. The Consultant should also develop a plan to inform key audiences throughout construction.
b. Suggestions for Medium Public Sensitivity: Identify the key stakeholders, residents and property owners within 1,000 feet of the design site and procure contact information to maintain dialogue with them.

Develop and distribute periodic newsletters to inform the public of the project’s need, schedule and any associated impacts. Invite them to presentations at local government entities or public meetings. When there is little new activity that needs to be reported, consider notifying the public with a postcard or letter.

Develop a project Web site and include the URL on all communication materials. Work with neighborhood and business leaders within the area around the pump station to develop acceptable mitigation measures. Participate in existing community meetings and/or schedule public outreach meetings to allow public design input.

Provide advance public notice prior to any surveying or other noticeable activity. The Consultant should also develop a plan to inform key audience throughout construction.

c. Suggestions for High Public Sensitivity: Identify the key stakeholders, residents and property owners within 1,000 feet of the design site (or within obvious geographic boundaries) and procure contact information for ongoing communication. Outreach may involve the distribution of fact sheets to individuals upon purchasing property in the neighborhood and representatives from environmental, taxpayer, business and other advocacy groups, as appropriate.

Develop and distribute frequent newsletters to inform the public of the project’s need, schedule and any associated impacts. Invite them to presentations at local government entities or public meetings. When little new activity needs to be reported, consider notifying the public with a postcard or letter.

Develop a project Web site and include the URL on all communications materials. The Web site should include an easy-to-process form to provide input to the Consultant. Public inquiries and project team responses should be filed for official legal record.

Work with community and, as appropriate, regional leaders within the affected geographical area of a pump station to develop acceptable project features, including access, aesthetics, noise, odor and safety. The Consultant should also consult with public safety officers regarding facility design to discourage loitering and vandalism.

Beginning early in the design phase, the Consultant should hold public meetings and continue public meetings through project completion. Public meetings should be held in a location convenient for the community. These meetings should be held at key engineering milestones for public input that can make a meaningful contribution to the project design.
Provide advance notice to the community of pending, highly visible project work, such as extensive soil sampling or marking trees for removal. This notice should be planned to ensure it is included in project newsletters, announced at public meetings and to community activists.

Conduct media relations at key project milestones. Develop calendar press releases to notify the community of public meetings; develop fact sheets to discuss difficult technical concepts.

In high public impact projects, the Consultant should consider organizing a Public Advisory Committee. The Consultant would facilitate Public Advisory Committee meetings. This committee should consist of key neighborhood and community activists, local government agency representatives and others who have a key stake in the project. The Public Advisory Committee would give design recommendations and input, and construction-related information. The Consultant should also develop a plan for ongoing communication and involvement of key stakeholders during construction.

5.2.7 Public Outreach Recommendations: As a general rule, whether the project is a low, medium or high public sensitivity project, the Consultant should adhere to the following recommendations during design to help gain public support.

a. Start Early: The Consultant should begin outreach at the early stages of design to allow public input before commitments to specific design concepts are made. Early outreach allows the Consultant to gauge the acceptability of a given project and helps identify potential fatal flaws and public opposition to avoid last-minute changes. Last-minute changes can result in delayed project schedules, adding additional cost to the project and, in some cases, negatively impacting overall system operations.

b. Inform the Public: Generally, the public is not familiar with modern pump station features and how they operate, or the role of a pump station in the sewer collection and conveyance system. A well-informed public is more likely to accept the project’s need and work with the Consultant to reasonably accommodate its presence in the community. When appropriate, the Consultant may invite community activists to tour a pump station similar to the one being built in their neighborhood to acquaint the public with the project. This can further public understanding of the project and provide an opportunity to build a trust relationship between the District and the community it serves. This approach has proven successful in other communities in Northern California.

c. Work with Community Leaders: Public outreach should focus on working with the community on each program to reflect community sentiment and attitudes. This will help build public support from residents and other stakeholders. This outreach should involve inviting input from city councils, local planning advisory councils, neighborhood associations, chambers of commerce and other community interest groups.
(1) Impartiality: To be most effective in serving the District’s and community’s needs, the Consultant must always show impartiality when interacting with the public. This enables a comfort level for positive community interaction.

(2) Maintain Databases of Key Contacts and Property Owners: The Consultant should develop a comprehensive list of stakeholders and property owners in the project vicinity in easily accessible databases. These databases include:

(a) Stakeholder database - consists of community activists, neighborhood associations, elected officials, advisory committees and councils, neighborhood associations, affected businesses and residences, media contacts, environmental groups, affected public agency representatives and others as deemed necessary. The Consultant should periodically update the database. These updates should include changes to mailing information after each mailing, public meetings, and extended periods of no outreach activity.

(b) Property database - generally includes all properties within a certain distance of the facility (e.g., 500 or 1,000 feet). Criterion are often determined on a case-by-case basis depending on considerations unique to the project area.

(3) Public Meetings to Provide Project Status Updates: Public meetings allow the community to express its concerns and provide input at various stages of the project. Each meeting should cover all relevant information. The ongoing primary meeting focus is usually information that identifies the need for the project.

The public’s primary concerns usually revolve around what impacts the project might have on their quality of life, including impact on traffic, environment and property values. Descriptive visuals, such as architectural renderings of pump stations and proposed traffic plans, should always be used to allow the public to see what the project will look like when finished and how construction may impact them.

(4) Establish Continuous Community Interaction: Continual community interaction is an important component of a successful public outreach campaign. The Consultant should consider holding frequent, smaller stakeholder meetings - in addition to public meetings - to communicate with community groups, businesses or landowners who may be impacted.

Stakeholder meetings, because of their intimate setting, can provide the opportunity to discuss the project in more detail. These meetings may provide opportunities to reconcile specific needs of these groups. Groups that might be included in stakeholder meetings are governing bodies, advisory committees and councils, neighborhood associations and those living or doing business within the project vicinity.
(5) Develop Informative Communications Materials: For effective communication, the Consultant should develop communications materials that convey key messages at strategic times throughout the project. These communication materials might include:

(a) Project newsletters or postcards to announce public meetings, provide project information or updates.

(b) Comment cards for public meeting attendees to provide input to the Consultant (should include either mailing address, phone number or e-mail address and name of contact to whom the cards should be sent).

(c) Project Web site (or Web page on existing site) to explain the project and provide periodic updates, project communication materials and meeting recaps (in pdf format), graphics (e.g., facility renderings) and even electronic form submittals or emails (e.g., to sign up for mailing list or comment on the project).

(6) Disseminate Media Messages: Media relations offer another opportunity to inform the general public in an economical way. Studies show that the public generally prefers media information more than traditional advertising or publications/materials developed directly by public or private sector organizations. The Consultant should consider the following media opportunities:

(a) Calendar press releases are one way to announce public meetings and important project events. A news release, complete with quotes from project team representatives, relevant maps and accompanying graphics, can help explain difficult concepts, improve communication and strengthen project acceptability or advance a position. The Consultant should accompany all news releases with a full pitch to targeted media outlets.

(b) When considering news release topics and to encourage the media to report the story, the Consultant should include human-interest and trend stories, in addition to the project’s key facts. For example, “Residents in the XYZ area will no longer have to worry about sewer overflows, thanks to increased sewage pumping capacity from the new XYZ pump station…."

5.3 CONSTRUCTION PHASE

5.3.1 The design phase is crucial in establishing the model for further outreach efforts and establishing public expectations. The construction phase outreach is critical as the project may be a daily public focus for months or perhaps years. Construction may have physical
impacts, so both proactive and timely responsive outreach is important to establish and maintain trust relationships with the community.

5.3.2 Many of the same issues facing design engineers need to be addressed again during the construction phase. During construction of a large infrastructure project, there may be public impacts such as traffic disruption, noise and dust. Through interviews with representatives from the County of Sacramento Construction Management Division (CMD) and research into past projects, the following key issues commonly faced during construction were identified:

a. Traffic control
b. Noise
c. Dust
d. Financial impacts to business owners
e. Accidents caused by construction conditions
f. Condition of road surface
g. Night work

5.3.3 In addition to the issues listed above, larger pump station projects can cause additional public impacts that must be considered by the Consultant. Some of these impacts include: noise and vibrations caused by pile driving, debris in streets adjacent to the construction area, and delays that may cause extended periods of lane closures and traffic speed reductions.

5.3.4 A discussion of key construction issues to be addressed in the Consultant’s public outreach program is presented below.

a. Traffic Control: Traffic control is a major issue during construction projects. The public understands that some traffic delays and lane closures are unavoidable in a large project. Without sacrificing public safety, attempts by the Consultant to reduce traffic controls when possible will be appreciated, can reduce public concern, and build public trust in the District.

Before traffic controls are set up within the project vicinity, the Consultant should meet with local residents, business owners and managers to discuss the plan and gather their input. As was discovered in the Folsom East 1B (FE1B) Interceptor construction, similar efforts produced public input that resulted in accommodations to hotel managers on Folsom Boulevard. The result was greater access to the hotels and trust in the District by the affected hotel managers.
The Consultant should provide adequate signage and clear direction in traffic controls to minimize driver confusion, facilitate the flow of traffic and help in reducing accidents. This is an opportunity to consider input gathered during design regarding peak traffic flows and local traffic patterns. Maintain a flexible approach to the design specifications, when possible.

b. Noise: Constructing pump stations can be noisy. Heavy and multiple machinery in operation can produce some level of noise impacts for nearby residents and businesses. The public usually prefers that noise be localized, minimized where possible (using less noisy machinery) and shortened in its duration. Careful planning by construction crews can, in certain instances, conduct the noisiest operations at times when there will be the least amount of disruption to normal public activities.

For example, for the Folsom East 3C (FE3C) Interceptor construction, many of the hotels near a construction site for a vortex structure voiced concern about noisy operations waking their guests, especially at night. With this in mind, the project team designed this work to take place in a short period of time over one weekend. Such public accommodation will help build future public cooperation for large District infrastructure projects.

c. Dust: Dust is an important issue for construction teams to resolve. The public, though not fond of dust, usually accepts dust impacts as long as it is controlled to avoid air quality risks or contamination of nearby structures.

To help retain public support, the Consultant should assure the public that dust mitigation specifications are being met and closely monitored. This includes the frequent use of street sweepers and keeping the soil in the project area sufficiently moist.

If dust impacts are expected to be above the normal standard, this information should be communicated to the public within the potentially affected area before construction begins. On occasion, specific actions should be considered. In one pump station project, the city of Sacramento provided temporary storage units for nearby homeowners who received large amounts of dust.

d. Financial Impacts to Business Owners: Depending on the scope of the project, some local business owners may claim the project has caused them to suffer financially. This is usually due to traffic controls limiting customer and delivery access to the businesses, expense of cleaning dust from vehicles for sale, and other reasons. These complaints are typically infrequent and, therefore, do not require substantial outreach. Extensive outreach about this issue may create additional claims for the District.

It is recommended that the District resident engineer keep claim forms so should a complaint be made via phone to a project team member or via the project hotline, the complaint can be addressed in a one-on-one basis by the Consultant.
e. Accidents Related to Construction: Based on historical information, reported accidents are rare. The Consultant should consider public input during design for inclusion into traffic control plans.

Once construction has begun, traffic controls should be modified as necessary, to better accommodate a smooth traffic flow. The Consultant may want to drive through the project area a few times after traffic controls have been set to ensure easy traveling. Signs encouraging slow vehicle speeds and accommodations for bicyclists should be posted at regular intervals.

f. Condition of Road Surface: In addition to placing traffic controls, the public may be concerned about the road surface condition in the project area. Extensive, large truck traffic, sometimes needed for pump station construction projects, may cause potholing or other deterioration of road conditions.

The public’s primary concern is that the road will be well maintained. To help construction crews avoid severely damaging roadways, the Consultant should consider access issues discussed in the previous sections. Design specifications should be flexible to allow accommodations that will suit the public’s needs.

g. Night Work: Certain areas with high density traffic, businesses or residences, are not conducive to high-impact daytime construction. Work in large, heavily trafficked roadways and intersections may contribute to traffic delays. Certain business or hotel districts may request special construction accommodations to better meet their customers’ needs.

In these and similar situations, night work and weekend work should be considered by the Consultant. As with any potential public accommodation by construction crews, potential public disruptions and complaints is one of many factors and should be given proper consideration. Any plans for night and weekend work should be communicated to the affected public at least one to two weeks in advance.

5.3.5 Public Outreach Recommendations: Public support is very important for a successful construction project. It is important to establish and maintain communication with the public throughout a construction project to retain the community’s support. The Consultant should consider the following public outreach recommendations:

a. Maintain and Update Databases from Design Phase: The Consultant should continue to add new contacts to the stakeholder database that was developed during design. New stakeholder contacts should be added as they become available throughout construction. Key community leaders’ contact information should be updated regularly.
During construction, it is important for the Consultant to provide regular project progress updates to those who will be impacted by construction. The Consultant may want to consider all properties within 500 to 1,000 feet of the work area, depending on development density of the project vicinity or use physical boundaries such as a river, thoroughfare or green belt.

b. Develop a Communications Emergency Response Plan: Before construction begins, it is important to have a plan of action should an emergency occur. This plan should include contact information including cellular phone numbers for key spokespersons, contractors, other project team members, media reporters and elected officials. A pocket guide that lists the key project team contacts should be developed for team members to carry with them at all times. All members of the project team should learn the basics of the plan. This plan could include important messages for a variety of potential emergency situations.

c. Hold Community Event to Kick Off Construction: Prior to beginning construction work, it may be beneficial to hold a kick-off or groundbreaking event to gain media attention and ensure the project receives positive public attention. The Consultant should determine the necessity and benefits of this event on an ad hoc basis. Factors such as anticipated public acceptability, public desire for the project (e.g., has the public been anticipating this project for a long time?) should be considered. When appropriate, involving a group in the project area, such as a local school, scout troop, etc., can help boost event attendance and project awareness.

d. Consider Public Meetings to Establish Community Interface: Public meetings may not need to be held as frequently/consistently during construction as during the design phase, but meetings can be an effective way for the Consultant to communicate face-to-face with stakeholders about important project milestones/updates. Whether to hold public meetings during the construction phase should be decided, based on the length of the project and potential public impacts. The Consultant should consider smaller stakeholder meetings if the project impacts are limited and focused on specific segments of the project area.

e. Keep Commuters Updated Through Use of Web Site: As identified previously, pump station projects, especially if connected to interceptor installation, can impact traffic flows. It is important that drivers receive frequent updates on construction schedules and any potential impacts to road conditions and traffic delays. It is recommended that the Consultant post weekly construction updates to a construction information Web site.

This Web site also might include an online sign-up process that allows commuters to receive weekly updates delivered directly to their e-mail inbox. The Web site URL should be included on construction signs posted in the construction area.
f. Develop Communications Materials: A project newsletter should be developed and continued throughout the construction phase to inform stakeholders of construction impacts and timelines, project updates, etc. As part of the public information conveyed in the newsletter, the Consultant should inform the public about certain “unpredictables” that may cause delays in construction schedules, such as weather, change orders, unforeseen utilities, etc.

Each newsletter, in a series of newsletters developed during the construction phase, should include contact information for M&O staff and other utilities. This will allow the public to address its concerns to the appropriate people.

1. In addition to listing M&O/utility contact information in the newsletter, the Consultant should consider developing give-away items that list essential phone numbers, such as refrigerator magnets.

2. As appropriate, the Consultant should send flyers of construction developments (i.e. noise impacts, road detours or closures, etc.) to specific stakeholders who are directly impacted, such as large landowners, business owners, etc.

3. The Consultant should develop a project fact sheet that outlines the who, what, where, when, why, and how information and distribute the fact sheet at public meetings and other public events.

g. Design and Place Construction Signs in Project Area: Prior to beginning any construction work, the Consultant should develop signs that clearly state the project name, anticipated end date and contact information (such as a hotline). The signs should be graphically designed to get the attention of drivers. If construction impacts business driveways, the signs should state that the areas are “Open for Business” and direct traffic through the appropriate detours.

h. Set Up Project Hotline: The Consultant should set up a project hotline that includes procedures for handling daily phone traffic and emergency situations. The procedures should be delivered to the contracted answering service and should be updated regularly as project updates become available.

As part of this hotline service, a priority should be placed on responding quickly to public inquiries, which will instill public confidence in the District. Emergency calls should be responded to immediately. The Consultant should respond to all non-emergency calls within 24 hours of the original call.

The Consultant should maintain the project hotline so people can call for project information and to log complaints. The hotline number should be included on all communication materials. The Consultant should keep a log of complaints made during construction and a member of the team should individually contact those submitting complaints.
i. Develop Construction Fact Sheet: At the onset of construction, it is important that the Consultant develop a fact sheet that communicates the basic facts about the project, such as the project need, description and location; key contacts for information; traffic controls; project schedule; and, planned work hours. The fact sheet should be maintained and updated by the Consultant, as necessary, as the project evolves.

The fact sheet can serve as a quick introduction of the project to members of the media and the public. If more detailed answers are required, the Consultant will need to provide this information at a stakeholder meeting or in a one-on-one setting.

j. Keep Key Stakeholders Informed: The Consultant should continue one-on-one stakeholder meetings with individuals and groups acquainted with the project during design, that may be impacted by construction. It is important that these stakeholders feel they are being informed on a regular basis. The Consultant should consider cost-effective methods for notifying these target audiences, such as consistent bi-weekly or monthly e-mail updates (depending upon the pace of construction).

k. Communicate to Public through the Media: The Consultant should be proactive in notifying the public when certain aspects of the project may impact them. The media offer a good vehicle for this, especially when the Consultant desires to convey a broad message to a large audience in an economical way. Building relationships with reporters will help the Consultant obtain positive and fair coverage about the project. Calendar releases should be used to publicize public meetings and events. News releases can be developed to alert the media to more significant information.
CHAPTER 6 – SUMMARY OF DESIGN CRITERIA, STANDARDS, AND GUIDELINES

6.0 GENERAL

6.0.1 The following chapter contains design criteria, standards, and guidelines to be used by Consultants in the development of pump station design documents.

6.1 HYDRAULICS

6.1.1 Hydraulic design criteria, standards, and guidelines are summarized below. The classification of pump stations and various hydraulic design considerations are also presented.

6.1.2 Classification: Design criteria for pumping stations vary depending on size. In addition, considering the critical nature of certain stations and the potential consequences of failure, additional features may be warranted. A discussion of pump station classifications as a function of capacity (size) and criticality (risk) follows below. For reference, classifications should consider the ultimate configuration of the station. Phasing of specific improvements may be possible depending on District input.

a. Size: Pumping station capacity can be defined in terms of hydraulic capacity, along with pump drive horsepower. This distinction is illustrated in Table 6-1. Pumping capacity refers to firm pumping station capacity or capacity that is available under all operating conditions (e.g., one pump out of service).

<table>
<thead>
<tr>
<th>Classification</th>
<th>Pumping Capacity</th>
<th>Pump Driver Horsepower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>&lt; 4 mgd</td>
<td>&lt; 30 hp</td>
</tr>
<tr>
<td>Medium</td>
<td>4 – 50 mgd</td>
<td>30 - 200 hp</td>
</tr>
<tr>
<td>Large</td>
<td>&gt; 50 mgd</td>
<td>&gt; 200 hp</td>
</tr>
</tbody>
</table>

From another perspective, in the District, small pump stations are served by collector or trunk sewer systems. Medium pump stations are served by trunk or interceptor sewer systems. Large pump stations are served by interceptor sewer systems only.
b. Risk: In pump station operation, the focus of the District is to minimize risk to the environment and impacts to public health. Because of the regulatory climate and potential fines associated with wastewater spills, the risk of pump station failure becomes a key consideration in developing facility design criteria. Potential risk will largely dictate facility requirements. As an example, the location of a pump station relative to a creek or drainage facility as compared to a sensitive waterway such as the American River will determine the relative level of risk involved in a spill. Proximity (or location) should be reviewed in terms of high water levels in a wet well versus the lowest manhole rim elevation in the collection system, recognizing that a pump station failure could lead to a collection system spill. Similarly, economic impacts to commercial enterprises such as a regional mall caused by spills also play a part in determining the potential level of risk. Disruption of institutional activities can also be a factor in subsequent risk classification. These “relative” factors for establishing risk are summarized in Table 6-2. The Consultant is expected to address these issues and assess potential risk associated with a proposed pump station during preliminary design.

### Table 6-2

**Factors to be Considered in Establishing Risk**

<table>
<thead>
<tr>
<th>Risk Classification</th>
<th>Factors</th>
</tr>
</thead>
</table>
| Minimal             | 1 Residential area.  
                     | 2 No significant commercial facilities, hospitals, nursing homes, schools, or correctional institutions within sewer shed. |
| Medium              | 1 Large commercial facilities, hospitals, nursing homes, schools, or correctional facilities within sewer shed.  
                     | 2 Pump station failure would result in overflow to creek or drainage facility not directly tributary to American River, Folsom Lake, or drinking water source. |
| High                | 1 Large commercial facilities, hospitals, nursing homes, schools, or correctional facilities within sewer shed.  
                     | 2 Pump station failure would result in overflow to American River, Folsom Lake, or drinking water source. |

Risk can be mitigated or reduced through a number of measures:

1. Siting a pump station further away from a natural waterway.
2. Eliminating single points of mechanical or electrical system failure.
3. Providing redundancy such as standby pumps, two level controllers (preferably of different types), two PLCs, and pumps capable of operation if an alternator malfunctions.
(4) Furnishing an emergency power source, including automatic transfer devices.

(5) Providing emergency storage to allow for maintenance staff response time. Specific guidelines are discussed later in this chapter.

(6) Reducing repairs and down-time. For example, pumps would be selected to operate within their AOR (Acceptable Operating Range) at all times. Most of the time pumps should operate within their POR (Preferred Operating Range).

(7) Including provisions for containment (casing pipe and carrier pipe) for force mains crossing waterways.

Through the incorporation of multiple redundancy features, a pump station that would be classified as high risk because of location could then be considered a medium risk facility. A District goal for future pump stations is to minimize the number of high-risk facilities.

c. Matrix for Station Classification: Future pumping stations will be designed considering both size and the potential level of risk. Small pumping stations can be categorized as minimal, medium, and high risk, depending on the application of factors described in Table 6-2. Because of the nature of their size, medium and large pumping stations will only be considered as either medium or high risk. The results of this combined pump station classification are illustrated in Table 6-3. Pump station criteria will then be developed for the subsequent seven categories of facilities.

<table>
<thead>
<tr>
<th>Size</th>
<th>Minimal</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Large</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

6.1.3 Hydraulic Design Considerations: Hydraulic design considerations encompass numerous parameters, including capacity requirements, phasing, pump selection, storage considerations, wet well design, force main design, and pipeline features. Each is discussed below.

a. Capacity Requirements: Several factors affect pumping station capacity requirements. The extent of the service area and equivalent dwelling unit factors are used to estimate average wastewater flows. Peaking factors, along with allowances for infiltration and inflow, determine peak wet-weather flows (PWWF). The PWWF
determines the pump station capacity. However, the pump station inventory is dictated by the need to convey low flows effectively as well as phasing considerations. A discussion follows below.

(1) Limits of Service Area: To determine upstream tributary area to the pump station, the maximum depth of the collector, trunk, and interceptor sewers must be reviewed. In general, a maximum depth of 16 feet is preferred for collector systems for subsequent excavation and repair procedures by District staff. For reference, OSHA requirements for sheeting and shoring up to a maximum depth of 20 feet are relatively straightforward and routinely observed by District personnel. Greater depths increase construction costs, require a site-specific design for shoring, and can delay subsequent repairs. In general, the number of pump stations should also be minimized. This balance between number of pumping stations versus sewer depth may lead to the approval of deeper sewers. As an example, District staff has indicated a willingness to consider 30-ft deep sewers if this results in one pump station versus two. Additionally, pump stations should be located where there is the least risk based on criteria in Table 6-2. Approval of pump station location, service area limits, and sewer depth is anticipated from the District prior to initiation of final design by a Consultant.

(2) Equivalent Single-Family Dwelling Unit Factors – Land Use Considerations: To determine the equivalent single-family dwelling (ESD) unit factors, the land use for a pump station service area must be determined. The District uses the following land use unit flow rates to determine ESDs:

(a) Low Density Residential 6 ESDs/acre
(b) Medium Density Residential 15 ESDs/acre
(c) Non-Residential (Commercial/Industrial) 6 ESDs/acre
(d) Transit-Oriented Development 11 ESDs/acre

(3) Estimating Wastewater Flows: The equations listed below are used to determine the dry-weather (DWF) and PWWF for future pump stations. The PWWF is the sum of the base wastewater flow (BWF) times a peaking factor (PF) plus the rainfall dependent inflow and infiltration (RDI/I) and groundwater infiltration (GWI). The BWF is typically the average dry-weather flow. The equation is as follows:

(a) PWWF = BWF (PF) + RDI/I + GWI

(4) The average dry-weather flow (DWF) is equal to 310 gpd per ESD times the number of ESDs per acre times the number of acres. ESDs per acre are a
function of land use as described previously. The average DWF is calculated based on acreage as follows:

(a) Average DWF = 310 gpd/ESD * ESD/acre*acres

(5) For average DWF between 0.1-10.0 mgd, the peaking factor (PF) is as listed below, with a minimum value of 1.2:

(a) PF = 3.5 -1.8Q^{0.05} where Q = average DWF

(6) For average dry-weather flows greater than 10 mgd, the peaking factor is calculated as follows, with a minimum value of 1.2:

(a) PF = 3.3-1.8Q^{0.04} where Q = average DWF

(7) In most sewer systems, infiltration and inflow (I/I) is the dominant factor in determining PWWF. The design event shall be a 10-year storm. The RDI/I for a 10-year storm is as follows:

(a) Existing Areas 1,400 gpd/acre
(b) New Development 1,000 gpd/acre

(8) Generally, GWI is very small compared to RDI/I flows in the sewer system. Based on data analysis conducted by the District, the peak GWI flow for the entire service area was projected as 17 mgd in 1990. This flow is equivalent to a unit flow of up to 500 gpd acre based on geographical location. Thus, the following values should be used for GWI:

(a) Natomas (west of main drainage canal) 500 gpd/acre
(b) All other areas west of UPRR Row 200 gpd/acre
(c) All remaining areas 0 gpd/acre

(9) Low-flow conditions should also be incorporated into the pumping station wastewater flow estimate. As illustrated in Figure 6-1, adapted from the CSD-1 Sewerage Facilities Expansion Master Plan, a sewer shed experiences a diurnal curve. The ratio of the average flow to the minimum flow is approximately 0.3. This low flow condition should be accommodated in the selection of individual pumping capacities.
SEWER SHED DIURNAL CURVE

FIGURE 6-1
SEWAGE PUMP STATION DESIGN MANUAL
PSDM

SEWER SHED DIURNAL CURVE
b. Phasing Considerations: If a pump station is intended for the ultimate development of a project being built in phases, consideration shall be given to the various flows that will occur at the different project phases. Pump selection should be based not only on the ultimate capacity requirements, but also on the interim development phase flows. The Consultant should carefully analyze pump station phasing versus development phasing to determine the most cost-effective approach. As an example, consider the use of impellers of minimum diameter in early stages and maximum diameter impellers at later stages. Other guidelines include the following:

(1) To accommodate low flow (or dry weather) conditions, it may also be desirable to add a jockey pump, particularly if pipe friction at maximum flow is a large portion of the total design head (TDH). A jockey pump is a low capacity pump that is used to avoid long detention times in the wet well and to optimize the operation of larger capacity, higher horsepower units.

(2) Consider piping for larger pumps but fitted with small pumps initially to be eventually replaced with larger machines. Also, consider allocating space (and pipe penetrations) for a future pump. In addition to the pump station, dual force mains may be needed to accommodate project phasing and to provide flexibility for both small and large flows. Dual force mains also provide a way to maintain one force main while keeping one in service. As an additional benefit, greater utilization of force main capacity with dual mains may reduce the potential for odor generation.

c. Pump Selection: Pumps should be selected to operate under the full range of projected system hydraulic conditions. Evaluation of both new and aged pipe conditions should be used to determine the limits of pumping conditions while minimizing opportunities for pump runout. Pumps and impellers should be selected so that the pump operates within the Preferred Operating Range (POR) for the most common flow rates and within the Acceptable Operating Range (AOR) for all flow rates. The POR is considered to be within 60-115% of the best efficiency point.

d. Storage Considerations: Because of land area requirements, aesthetics and maintenance concerns, large-scale storage of wastewater at pumping stations is rarely practiced. When used for equalization purposes, storage may prove economical on a first cost basis as a means of downsizing mechanical and electrical equipment to meet average design conditions versus peak flow requirements. Daily use of equalization storage in a fill and empty mode may create significant maintenance activities that largely cancel any savings in capital cost. Therefore, storage for equalization purposes is not recommended unless specific justification, including an analysis of recurring maintenance costs, demonstrates clearly an economic advantage.

Wastewater storage for emergency purpose, however, is appropriate as a means to mitigate pump station failures. Within the District, these failures have occurred due to the following:
(1) Communication failures within the SCADA system

(2) Power failure

(3) Instrumentation (level measuring components, PLC, OIPs) malfunctions

(4) Electrical component failure

(5) Mechanical equipment failure (check valves, pump volutes, bubblers)

To avoid or mitigate these failure modes, a number of preventative measures can be implemented. These include:

(1) Emergency storage

(2) SCADA system design that allows for continued pump station operation even when a communication failure occurs

(3) Installation of emergency power generation equipment

(4) Furnishing of back-up instrumentation systems

(5) Avoiding single points of failure in electrical distribution systems

(6) Improving mechanical reliability through additional redundant equipment

Specific criteria for emergency storage as a function of pump station size and risk are presented in Table 6-4.

<table>
<thead>
<tr>
<th>Pump Station Classification (Size/Risk)</th>
<th>Minimum Emergency Storage Detention Time (hr)</th>
<th>General Location</th>
<th>Sensitive Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small/Minimal</td>
<td>&gt;8</td>
<td>&gt;8</td>
<td></td>
</tr>
<tr>
<td>Small/Medium</td>
<td>4-8</td>
<td>6-8</td>
<td></td>
</tr>
<tr>
<td>Small/High</td>
<td>4</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Medium/Medium</td>
<td>4-8</td>
<td>8-12</td>
<td></td>
</tr>
<tr>
<td>Medium/High</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Large/Medium</td>
<td>4-8</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Large/High</td>
<td>4</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

\* Detention time at ADF in hours.

Emergency storage can be provided either on-line or off-line. On-line storage consists of additional capacity in the upstream gravity sewers that feed the pump station (i.e.,
oversizing of collection systems, surcharging of manholes) and supplemental storage in the wet well. Off-line storage is available in detention basins. Preference should be given to on-line storage, particularly in the collection systems, to minimize subsequent site requirements and to mitigate wet well operational issues.

e. Design of Wet Wells: The wet well is defined as the operational sump for a lift station’s pumping equipment. Criteria for wet well sizing, configuration of wet wells, and hydraulic design considerations are discussed below.

(1) Sizing of Wet Well: Wet wells with constant speed (C/S) pumps should be sized based on the equation below. For variable speed pumps, operational volume should be evaluated considering minimum pump speed and cycle time.

(a) Wet Well Operational Volume \( V \) = \( PWWF (Q) \times t \)

\[ \frac{4}{4} \]

In the above equation “Q” is pump station flow in gpm and “t” represents the interval between pump starts in minutes. Starts per hour for non-submersible pump motors in a dry pit arrangement should be limited to 6 starts per hour for 200 horsepower or less. Larger dry pit motors would be limited to 3-4 starts per hour. Submersible motors in a submerged application would have more allowable starts per hour due to improved heat transfer. Submersible motors that are 100 horsepower or smaller can have up to 8 starts per hour. Larger submersible motors should be maintained at a maximum of 6 starts per hour.

(2) Wet Well Configuration: If multiple circular wet wells are provided at a station, each wet well should be furnished with an equal number of pumps. For small pump stations, a circular wet well is recommended. The wet well should be designed with straight side walls and a flat bottom. Fillets should be provided at the interface between wall and floor (see Figure 6-2). Because it is a hazardous, confined space, regular access and entry into the wet well by District maintenance staff for cleaning purposes are not recommended. Instead, frequent (bi-weekly) monitoring-inspection, washing of the wet well sides from the deck level with at least 15 gpm of water at no less than 65 psi pressure, together with manual pump down of the wet well to remove scum are the proposed maintenance practices to optimize wet well capital and recurring maintenance costs.

For medium and large pump stations self-cleaning, trench-type wet wells are recommended as shown in Figure 6-3. Advantages are: (a) they can be cleaned of scum and sludge in about five minutes without manual labor, and (b) they
NOTES:
1. LOWER APPROACH PIPE SO THAT INVERT IS APPROX. D/2 BELOW LOW WATER LEVEL.
2. GUIDERAIL SHALL BE MADE OF 316 SS AND SHALL BE SIZED PER PUMP MFR WITH INTERMEDIATE SUPPORT.
3. PAD, SS ANCHOR BOLT ASSEMBLY, AND LOCATION SHALL BE DESIGNED PER MFR REQUIREMENTS.
NOTES:
1. FLOW SPLITTER AND FILLETS MAY BE OMITTED IN A TRENCH LESS THAN 1.0 M (39 IN) WIDE.
2. \( r_1 \geq 2.33 \times \frac{V^2}{2g} \) WHERE V = VELOCITY AT TOP OF RAMP (2D MIN.), \( r_2 \geq 1.25d \)
3. 1.2 M/S (4 FT/S) MAX WET PIT PUMPS, 1.0 M/S (3 FT/S) MAX DRY PIT PUMPS
4. \( \varepsilon \geq 45^\circ \) SMOOTH SURFACE (PLASTIC LINING)
5. \( \varepsilon \geq 60^\circ \) CONCRETE SURFACE
6. \( S \geq (1+2.3\varepsilon)D \)
furnish an excellent hydraulic environment for the pumps. Variable frequency drives (VFD) may be considered (1) to accommodate low flows, (2) to avoid sudden surges of flow that can disrupt downstream treatment facilities, (3) to reduce the required size of the wet well and reduce sedimentation, (4) to affect energy savings, and (5) to prolong the life of motors. Alternatively, C/S pumping can be accommodated in trench-type wet wells if an approach pipe is used for supplemental storage. Jockey pumps can be used in C/S pumping from trench-type wet wells, but only a life cycle analysis will determine whether their use is economical.

Sequent depths can be calculated from *Trench 2.0* available at [http://www.coe.montana.edu/ce/joelc/wetwell/](http://www.coe.montana.edu/ce/joelc/wetwell/). Recommendations in ANSI/HI 9.8-1998 or subsequent editions should be followed except that Figure 6-3 should take precedence over Figures 9.8.13 and 9.8.14 in the ANSI/HI publication. Numerical examples of trench-type wet wells for variable speed pumps and for C/S pumps and the approach pipe are located in Chapter 12 of *Pumping Station Design*. The examples can be simplified by using *Trench 2.0* and *Approach* in the website previously mentioned, [http://www.coe.montana.edu/ce/joelc/wetwell/](http://www.coe.montana.edu/ce/joelc/wetwell/).

Submersible pumps can be used either in the trench or in a dry pit. Those in trenches should be fitted with suction nozzles so that (1) the ledge for the discharge fitting is above the fillet and (2) at least four vanes can be installed in the suction nozzle to inhibit swirling. Vanes shall have smooth rounded edges to shed stringy material and should pass solids not larger than 3 inches in diameter.

(3) Hydraulic Design Considerations: Hydraulic design considerations include the avoidance of excessive submerged and free-surface vortices, excessive pre-swirl of flow entering the pump, non-uniform spatial distribution of velocity at the impeller eye, excessive variations in velocity and swirl with time, and entrained air or gas bubbles. These are discussed below.

(a) To eliminate off-gassing, turbulence, and air ingestion by the pumps, sewage should not be allowed to drop from the inlet to a water surface below the inlet. Sewage should instead be intercepted at an upstream manhole by an "approach pipe" laid on a steep gradient (of 2% slope or more) to a point of discharge. Its invert should be half a pipe diameter below low water level (LWL). The steep gradient should minimize the possibility of solids deposition. The approach pipe should be considered part of the wet well and not a sewer. The approach pipe, especially if one or two sizes larger than the upstream sewer, may contain as much as half of the needed active storage to keep the pump cycling frequency within the manufacturer's recommendations. The approach pipe can also serve as supplemental emergency storage.
(b) Inlet velocity should be less than 4 ft/sec with the axis of the conduit coaxial to the axis of the wet well. An approach pipe should be used for the inlet to any wet well with constant speed pumps (see Appendix C in ANSI/HI 9.8 and the numerical example in Chapter 12 of *Pumping Station Design*).

(c) The last five pipe diameters, the inflow pipe should be straight before entering the wet well. A vertical "target" baffle extending from above the high water level (HWL) to about D/2 below the inlet invert, 1.5 to 1.67 D wide, and located about D upstream from the first pump, reduce the strong inlet current and potential swirling.

(d) For C/S pumps, a 2% grade for the approach pipe is recommended for storage in trench-type wet wells. The hydraulic jump should be kept lower than the soffit of the pipe to avoid any appreciable air from entering the wastewater. The sequent depth should be kept to about 60% of the inlet pipe diameter.

f. Design of Pump Discharge Piping and Force Mains: Because the pump station system curve is largely dependent on the force main layout, design guidelines for piping systems are presented. Criteria for the design of force mains include various friction factors, velocity considerations, surge issues, and piping characteristics. Each is discussed below.

1. Hydraulic Factors: For sizing pipe and determining the head loss, the Hazen-Williams equation with $C = 100$ or the Manning’s equation with $n = 0.013$ for all pipe materials and sizes should be used. In developing a system curve for pump selection, a condition with a pipeline value of $C = 145$ should be evaluated to verify that the system can operate at all intermediate conditions between two scenarios (old and new pipe).

2. Velocity: At the design peak flow, with all pumps except the standby running, the maximum velocity in the force main should not exceed 8 ft/sec. Some exceptions are possible for discharge lines shorter than 10 feet. Minimum velocity in the force main with only one pump running shall not be less than 2 ft/sec or 3.5 ft/sec depending on continuous versus intermittent pumping operations. Additional velocity design criteria can be found in the *ASCE Journal of Hydraulic Engineering, (April 2003)* for the velocity required to keep sand moving up slopes in inverted siphons.

Vertical discharge piping on pumps with VFDs should be sized to maintain minimum design velocities during a programmed initial flushing period. VFDs should be designed and programmed to provide a flushing velocity in the force main of at least 3.5 ft/sec at the beginning of each pumping cycle. After an initial flushing of the maximum practical duration, depending on the wet well volume, the pumping velocity may be reduced. Velocities should not be allowed to fall below 2 ft/sec.
(3) Surge Issues: Surge analysis, or hydraulic transient analysis, for the pump station, force main, and appurtenances (air release valves) should be performed, if one of the following conditions exists:

(a) Pumping total dynamic head (TDH) is greater than 40 feet and flow exceeds 500 gpm.

(b) Pipelines have high points or “knees”. Power failures can cause a partial vacuum at the knee and can result in column separation (with only water vapor in the pipe at the knee).

Surge mitigation can be accomplished by the following control strategies:

(a) Reroute force mains to avoid knees.

(b) Use pump control valves that open and close gradually.

(c) Increase rotating moment of inertia by adding a flywheel.

(d) Use engine drives on some pumps so the entire system cannot fail at once.

(e) VFDs guard against continual pounding at startup and shut down but do not protect from power failure.

(f) Add vacuum relief valves at critical points.

(g) Hydropneumatic tanks. If specified, hydropneumatic tanks should be designed, fabricated, and tested in accordance with the ASME Code for Unfired Pressure Vessels, and should be equipped with compressed air system controls to maintain air-to-water ratio.

(h) Air-vacuum valves

(4) Piping Characteristics: Suction piping diameter to the pump should be at least one size larger than the pump inlet diameter.

g. Pipeline Features and Appurtenances: In terms of changes in direction, multiple 45 degree or 22.5 degree bends should be used in lieu of short radius 90 degree fittings. Force mains should be designed so that the pipeline is always full and that no point in the vertical alignment is located above the energy grade line. The number of low and high points should be kept to a minimum because high points can lead to air traps and sulfide corrosion. If high and low points are unavoidable, air relief/vacuum and blowoff valves should be installed respectively at high and low points. If possible, blowoff valves should discharge to a sanitary sewer manhole. Cleanout or flushing...
attachments to facilitate maintenance and provisions to prevent vandalism should be provided. Valve location versus the pipe cross section should consider the potential for grease accumulation. Because air relief valves require frequent maintenance, the valves should be located outside of the travel way as much as possible. The valves should be identified with a pump station diameter, diameter of force main, and location of the force main.

At the pump station a 2-inch ball valve should be provided on the top of the pump volute discharge to allow removal of air after servicing and prior to placing dry well pumps back in service. The vent line should be plumbed to discharge to the wet well or sump pump.

To avoid shearing force mains due to differential settlement, flex couplings should be used on pipelines between the pump station structures and vaults. Thrust forces in force mains should be mitigated through joints that are restrained or anchored to prevent excessive movement and joint separation. Provisions for launching and retrieving cleaning pigs should be considered in the design for pipe diameters 24 inches and smaller. Pig launching facilities may be as simple as a pipe wye or more elaborate, with a special launch chamber, bypass piping, and valves. In either case, gauges should be attached to monitor pressure. Retrieval facilities may also be elaborate or simple. Elaborate retrieval devices are usually mirror images of the launch device. Simpler retrieval methods can include baskets, traps, or screens placed in the receiving manhole.

Dual force mains can be considered for phasing purposes along with obtaining proper velocities under all flow conditions. Dual mains also make it possible to empty a force main for maintenance or repair purposes. Provisions for pipeline draining and flushing should be included in the force main design. Dual force mains may require automated control valves linked to pumping equipment operation.

For force main discharges, the force main should enter the receiving manhole with its centerline horizontal and an invert elevation below the gravity line to ensure a smooth transition of flow to the gravity flow section. In no case, should the force main enter the gravity system at a point more than one foot above the flow line of the receiving manhole. The design should minimize turbulence at the point of discharge and it should keep the force main completely full at all times. Consideration shall be given to the use of inert materials or protective coatings for the receiving manhole to prevent deterioration from hydrogen sulfide or other chemicals. These conditions are especially likely to be present if the force main is long (more than four hours of detention time).
6.2 CIVIL AND SITE DESIGN

6.2.1 A discussion of pump station civil and site design includes the following: a) site requirements; b) site piping connections; c) station cleaning, drain, and washdown facilities; d) landscaping and irrigation; e) security; and, f) odor control.

6.2.2 Site Requirements: The size of a proposed pump station site will vary depending on the facility configuration and access requirements. Design criteria includes the following:

a. A minimum of 50 ft separation from the pump station structure (i.e., wet well/dry well) should be provided to the property line and/or adjacent facilities.

b. Access to pump stations is critical for District maintenance and operations (M&O) personnel. Pump station site design must include space to facilitate service equipment. This is in addition to the permanent on-site equipment including an emergency generator. Space for a standby generator should be reserved whether the unit is fixed or portable. Access should be provided around the entire perimeter of the pump station for required maintenance equipment.

c. All maintenance vehicles anticipated to service the station should park on-site. Specific requirements are summarized in Table 6-5. No street parking (off-site) for maintenance vehicles should be assumed. Adequate clearance from overhead power lines to allow for the safe operation of a crane should be provided.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Access Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>1-2 parking stalls sufficient for vehicles, crane, boom truck, or vacuum truck</td>
</tr>
<tr>
<td>Medium</td>
<td>2-5 parking stalls sufficient for vehicles, crane, boom truck, or vacuum truck</td>
</tr>
<tr>
<td>Large</td>
<td>Minimum of 5 parking stalls for crane or boom access</td>
</tr>
<tr>
<td></td>
<td>Sufficient paving area and clearance within the secure site area to permit full movement and operation of a suitable crane that may be required to remove installed pumps.</td>
</tr>
</tbody>
</table>
d. For reference, the District currently utilizes six different types of boom trucks. Maintenance is usually performed with either a three-ton or nine-ton boom truck. The boom lengths are 8 feet-10 inches for the three-ton truck and 34 feet for the nine-ton truck. A minimum design turning radius of 42 feet should be used for an 8 feet wide by 30 feet long truck. Site design should accommodate access to pump hatches, manholes, and vaults without vehicles being required to back over structural elements. Access provisions should account for vaults and covers in the open position. Vehicles (including chemical delivery trucks) should be able to turn-around within the site for subsequent egress. Access should be available through a 24 foot wide public right-of-way (R/W) and minimum 16 foot wide paved road.

e. The maximum slope for access roads should be 15%.

f. The edge of any excavation to construct the pump station facilities should be set back a minimum of 200 feet from the toe of any flood control levee.

g. Above-grade equipment and piping should be protected by bollards.

h. Paving should be designed for H-20 loading.

i. Vaults should be designed to avoid designation as a confined space. Vaults that are six feet or deeper should have stairways or installed ladders with extensions per OSHA standards. A concrete pad should be placed around vaults which is suitable for confined space personnel retrieval equipment.

j. Facilities should be oriented according to prevailing wind direction and to minimize potential for hydrogen sulfide gases entering control building intake grills or electrical panels whenever possible.

6.2.3 Site Piping Connections Guidelines:

a. To accommodate minor settlement, buried piping joints should be push-on type or other comparable flexible type. Mechanical joints may be used on fittings. Restrained joints should be used to eliminate the need for thrust blocks. Based on District experience, flanged coupling adaptors should not be installed at pump stations. Flexible couplings or sleeves can be provided on inlet and discharge piping where piping enters through a pump station floor, foundation, or wall. Short 90-degree elbows are discouraged. Long sweep 90-degree or 45-degree elbows are recommended whenever possible.

b. In bypassing flow through emergency pumping, all small pump stations should include provisions for bypass pumping regardless of risk classification. Force mains should have isolation valves for temporary bypass pumping. The connection should be located in a valve vault. For small pump stations, an upstream manhole with bypass pumping connections should be provided to isolate the wet well. Bypass
pumping can be accomplished by District forces with portable pumps for flows up to 4 mgd.

c. Isolation valves should be provided in a separate valve vault on the discharge side of each pump for submersible pumps serving small and medium size pump stations. Large pump stations should have dual wet wells to allow for isolation without requiring bypass pumping. For large pump stations, an isolation sluice gate should be provided to isolate the wet well from inlet sewer. Similarly, isolation valves should be included on the inlet and discharge side of each installed pump in a dry well.

6.2.4 Station Cleaning, Drain, and Washdown Facilities: Provisions for wash-down, cleaning, and drainage are discussed below.

a. Station Cleaning/Wash Down Facilities: Potable water should be provided at each station for station cleaning and wash down regardless of station size. Service should be sized based on an intermittent demand up to 50 gpm. A backflow preventer should be provided for hose bibbs used for wet well washdown, isolating the service from all other water usage at the station. Potable water may also be needed for safety and sanitary facilities as required by station size. Hose bibbs for station cleaning and washdown should be installed at the following locations as applicable to station size:

(1) Adjacent to wet well at grade

(2) Within the dry well at pump deck elevation

(3) Within the dry well at valve deck elevations

(4) Adjacent to hydraulic system (where provided)

(5) Adjacent to hydropneumatic tanks

(6) Adjacent to emergency generator fuel storage tank

(7) Adjacent to emergency diesel-driven pump fuel storage tank

(8) Adjacent to chemical addition facilities

(9) Adjacent to odor control facilities

b. Drainage: Design guidelines include the following:

(1) Elevations of pump station ground-level finished floors and the top of submersible pump station wet wells should be designed for a minimum of two feet above the 100-year base flood elevation.
(2) The pump station site should be provided with suitable drainage facilities (drainage channel, detention basin, retention basin with pump station, or drainage pump station) to convey the 100-year storm event for on-site drainage.

(3) A minimum slope of 1% should be maintained for site drainage.

(4) Surface runoff should be drained to the site storm drain system. Water accumulating in vault boxes and trenches should be drained back to the wet well where possible. Sump pumps from dry wells or other vaults should be furnished where gravity drainage to the wet well is not possible.

(5) Secondary containment barriers around fuel or chemical storage facilities should be equipped with valved outlets to separate sumps. Accumulated rainwater should be collected in the containment barrier until inspected by the operator, then released to drain back to the wet well if not contaminated. When contamination is evident, provisions for removal using a vacuum truck should be provided.

6.2.5 Landscaping and Irrigation Guidelines: Guidelines for landscaping design include the following:

a. The exterior of the site should be landscaped. No landscaping should be provided within the interior of the site. The use of concrete and asphalt surfaces should be maximized within the enclosed pump station site in lieu of decorative landscape materials such as bark or crushed rock. Exterior landscaping should blend with the surrounding area.

b. Drought resistant landscaping should be provided. The use of turf and water-thirsty plants should be limited.

c. Low, slow-growing, disease-resistant plants should be planted. Ivy and thorny bushes are not allowed.

d. Fully automatic irrigation system providing head to head coverage should be provided. Pop-up sprinkler heads should be furnished.

e. Valves should be enclosed in lockable boxes.

f. Irrigation controls should be housed within the pump station in an aboveground structure or lockable enclosure unless the exterior landscaping will be maintained by non-District staff. Irrigation controls should be accessible for landscape maintenance personnel.

g. For large pump stations, provide the following:
(1)  Raised curbs (6 inches) in planting areas adjacent to sidewalk.

(2)  Screening shrubs adjacent to property lines abutting public streets.

(3)  Landscape design to assure the parking lot is 50 percent shaded in 15 years.

(4)  Exclude plants that will have large roots that prohibit pipeline construction.

(5)  Exclude protected plant species.

6.2.6 Guidelines for Security:

a.  Security fencing should be provided at all pump stations. Block walls with architectural treatment are preferred over a chain link fence. Long driveways to facilities should be avoided. The following should also be provided:

(1)  Double-wide access gate, minimum 14 feet.

(2)  Local area exterior lighting with switch and photocell.

(3)  Vandal-proof doors, vandal-proof lights.

(4)  Sargent locks for all buildings.

(5)  Gate entrance with key card access (Knox locks).

(6)  Gate entrance with key card access should be coordinated with the local fire department.

(7)  Vaults, manholes, and drains should be located inside the fenced pump station site.

(8)  Vaults should be provided with standard lockable, springloaded, double leaf access doors, and fitted with a safety net system.

b.  Supplemental security features as a function of station capacity are summarized in Table 6-6.
### TABLE 6-6
**Pump Station Security Requirements**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Security Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>Dead front electrical panel with intrusion alarm/signal transmission to District SCADA. Vandalproof latch.</td>
</tr>
<tr>
<td>Medium</td>
<td>Unauthorized entry alarms with signal transmission to District SCADA. Provisions for future installation of video cameras for remote monitoring of the site.</td>
</tr>
<tr>
<td>Large</td>
<td>Unauthorized entry alarms with signal transmission to District SCADA. Fence webbing or other screening may be required. Provisions for future installation of video cameras for remote monitoring of the site.</td>
</tr>
</tbody>
</table>

6.2.7 Criteria for Odor Control System Design: Criteria for odor control system design can be divided into the following areas: a) anticipated concentrations of odorous compounds; b) hydraulic considerations that will minimize the potential for odor generation; c) chemical addition; d) ventilation requirements for odorous air treatment; and, e) acceptable odor control systems. These topics are discussed as follows:

a. Anticipated Concentrations of Odorous Compounds: Hydrogen sulfide (H$_2$S) is the primary odorous compound of concern in wastewater pump stations. Typical H$_2$S concentrations range from zero to 700 parts per million volume (ppmv). Mercaptans and other organic sulfur compounds are present at lower concentrations. Odor issues are more severe in pump stations larger than 2 mgd; because wastewater travel times are long, anaerobic conditions are likely. Concentration limits of 0.0047 ppmv for H$_2$S and 0.0015 ppmv for mercaptans, the olfactory detection threshold for these chemicals, are recommended odor reduction objectives.

b. Hydraulic Considerations: Minimize or prevent production of odorous compounds.

(1) Design upstream sewers to maintain aerobic conditions in the wastewater by keeping velocities above 2 ft/sec at peak wet weather flow. For large trunks, a velocity of 3 ft/sec at peak wet weather flow is recommended.

(2) Performing frequent cleaning, using a high-pressure water lance to minimize grease and scum buildup on the wet well walls.
(3) Minimize turbulence of wastewater by avoiding drop inlets into the wet well.

(4) Match water elevations between sewer and wet well to avoid turbulent entry of the wastewater and off-gassing when variable-speed pumping is used. For constant-speed pumping, slope the approach pipe so that its invert is slightly below the low water level.

(5) Seal the wet well, whenever possible.

(6) Keep the wet well small enough to minimize stagnation and settling of solids.

(7) Design force mains for velocities of 3.5 to 4.0 ft/sec at least once per day, avoiding detention times greater than 3 hours.

c. Chemical Addition: Hydrogen sulfide generation can be minimized through chemical addition. Single or multiple chemical injection points should be evaluated for effectiveness. Reduction in sulfide generation is recommended at medium and large pump stations. Acceptable chemicals are as follows:

(1) Sodium hypochlorite

(2) Hydrogen peroxide

(3) Potassium permanganate

Storage volume of chemicals should be based on effective shelf life and most economical bulk delivery volume. The chemical storage and delivery schedule should assure there is always the equivalent of one week of chemicals available onsite to meet maximum design dosages over weekends. If a chemical handling and injection system is not installed initially, provisions for a system should be incorporated into the facility design for future construction.

A safety shower/eyewash station will be required at any chemical addition facility. Moreover, a clear and short pathway must be designed into the station such that operators seeking washdown after chemical exposure can quickly access these stations from a potentially hazardous area, such as chemical storage tanks, valves and pump manifolds.

d. Design criteria for chemical systems are summarized below:

(1) Sodium Hypochlorite
(a) Typical dosage: H$_2$S to sodium hypochlorite ratio from 1:7 to 1:15

(b) Maximum of 15 days of storage for 12.5% solution.

(c) Dilution to 6-8% solution recommended to lower decomposition rate.

(d) Should be stored in a cool and dry area, typically indoors.

(2) Hydrogen Peroxide

(a) Typical dosage: H$_2$S to hydrogen peroxide ratio from 1:2 to 1:8.

(b) 3%-solution stable under normal storage conditions. 20-52%-solution stable only when cool and pure.

(c) Should be stored in a cool and dry area, typically indoors.

(d) May need to be diluted.

(3) Potassium Permanganate

(a) Typical dosage: H$_2$S to potassium permanganate ratio from 1:6 to 1:12

(b) Stable crystals

e. Ventilation Requirements for Odorous Air Treatment: Ventilation requirements for pumping stations should reflect the following:

(1) Confined space status should be assumed for the wet well as defined by OSHA. For ventilation purposes, the minimum number of air changes per hour should be six (6). If entry to the wet well is necessary (e.g. for cleaning or maintenance), a portable fan should be used to increase the number of air changes per hour to the minimum requirements established by NFPA 820. The minimum number of continuous air changes for the dry well is six changes per hour.

(2) Depth of the air duct in the wet well should be set to avoid entry of wastewater into the duct during periods of high water level. Duct shall be constructed of fiberglass reinforced plastic (FRP).

(3) Ventilation fan should be a centrifugal type with adjustable belt drive.

f. Odor Control Systems Design Criteria: Design criteria for foul air treatment should include:
1. Minimum residence time for the foul air in the treatment unit
2. Maximum loading rate of the treatment unit
3. Maximum influent hydrogen sulfide and mercaptans concentrations
4. Minimum removal efficiency of 99% for H₂S and 90% for organic sulfur compounds.

g. Acceptable foul air treatment processes are as follow:

1. For small pump stations:
   a. Modular biofilter: maximum loading rate of 7.5 scfm/ft².
   b. Oxidizing dry air scrubber

2. For medium pump stations:
   a. Activated carbon (for hydrogen sulfide concentrations less than 10 ppmv): minimum residence time of 3-4 seconds.
   b. Closed-bed biofilter

3. For large pump stations:
   a. Activated carbon (for hydrogen sulfide concentrations less than 10 ppmv): minimum residence time of 3-4 seconds.
   b. Closed-bed biofilter

4. In pump stations where air release valves are used, carbon cartridges may be used to reduce odor emissions.

### 6.3 STRUCTURAL DESIGN CRITERIA

6.3.1 Structural design criteria are presented for Electrical, Control, Standby Generator Buildings along with buried facilities such as wet wells. Each is discussed below.

6.3.2 Electrical, Control, Standby Generator Buildings: These buildings are typically non-occupied support buildings consisting of either cast-in-place concrete, tilt-up concrete, or fully grouted masonry bearing walls with steel or timber framed roof framing systems. The intent of these buildings is to protect the electrical-mechanical equipment from the elements. Specific guidelines are as follows:
a. The exterior of these buildings can consist of either exposed masonry or concrete or a stucco type of finish system. The roofing material ranges from built-up roofing, to composite shingles, to concrete tiles, to standing seam metal roofing. All roofing materials and the installation of these materials should conform to the requirements specified in the National Roofing Contractors Association (NRCA) *Roofing and Waterproofing Manual*.

b. These buildings should be fully enclosed, sealed, and weather stripped to prevent rain water from entering the interior. The construction of the building exterior walls should achieve a minimum insulation rating of R-19. The building ceiling should have a minimum R-30 insulation rating. A vapor capillary break should be placed below the building slab on grade to prevent weeping of subgrade water into the building.

c. If access to the roof is required for removal or maintenance of equipment, fall protection anchors must be located where personnel can attach anchors before stepping on the roof. In the areas of the roof access hatch, the roof surfaces should provide traction and adequate footing for safety.

d. The doors for these buildings will typically consist of exterior rated steel doors conforming to the requirements specified in Steel Door Institute (SDI) 100 requirements. Any fire doors required should conform to NFPA 80 requirements. The associated door hardware should be at a minimum commercial rated hardware. Door pulls, cover plates, and striker plates should be stainless steel. Locks should allow personnel to open and secure the door from the inside. Locks with interchangeable type cylinders should be provided and should be dead bolt type. Hardware for fire doors should be UL listed. Any glass or glazing associated with these buildings including windows should conform to the following standards:


2. Sealed Insulating Glass Manufacturers Association (SIGMA), *TM-3000 Vertical Glazing Guidelines* and *TB-3001 Sloped Glazing Guidelines*

e. All glass and glazing should be fabricated and installed for normal thermal movements and wind loading. Normal thermal movement is defined as that resulting from an ambient temperature range of 120°F and from a consequent temperature range within the glass and glass framing members of 180°F.

f. Interior concrete floor surfaces should be protected with a sealer-hardener coating. Nonskid-type floor coatings should be provided around pumps and equipment where maintenance will be performed. Floors should be sloped to floor drains or sumps at a slope of not less than 1/8-inch per foot (1%), or greater where warranted.
g. Floor gratings in all areas except the pump station wet well should be aluminum. Floor grating in the pump station wet well should be fiberglass reinforced plastic. Floor drains or gratings should be located to minimize drainage across the floor. Floor drains should be provided in every room except the generator and control room.

h. The Engine-Generator Room should be equipped with monorails with trolley hoists for routine maintenance functions. Doors should be sized for generator removal. Removal of generators and engines should be accomplished by portable equipment provided by others. Provisions should be included for access hatches, lifting hooks, hoisting systems, roll-up doors and other means to provide maintenance.

i. An intermediate platform should be provided for access to vertical wastewater pump drives greater than 100 hp in size.

j. Lifting eyes attached to the ceiling should be provided directly above the valves and equipment items weighing more than 100 lbs that are not accessible by bridge cranes or monorails. The Consultant should ensure adequate horizontal and vertical clearance between the overhead crane hoists and other installed equipment to allow lifting and moving motors and pump equipment to the station doors via the monorail.

k. Structural design of the building should conform to the following design codes.

(1) 2001 California Building Code (CBC)

(2) American Concrete Institute (ACI) 318, Building Code Requirements for Structural Concrete

(3) American Institute of Steel Construction, Manual of Steel Construction

(4) Concrete Masonry Association of California and Nevada, Design of Reinforced Masonry Structures

(5) National Forest Products, National Design Specification For Wood Construction


l. Loading of these buildings for structural design purposes should conform to Section 16, Structural Design Requirements of the CBC and include as a minimum the following:

(1) Dead Load: Self Weight of Structural Elements
Mechanical Equipment and Piping Loading
Electrical Equipment and Conduit Loading
Fire Sprinkler Loading as Appropriate
(2) **Live Loads:** Minimum Roof Live Loading of 20 pounds per square foot (psf)
Other Live Loads as Appropriate

(3) **Lateral Loads:**
- Seismic Loading – Zone 4
- Wind Loading – Basic Wind Speed 90 mph

(4) Deflection of grating and cover plate should be limited to \( \frac{1}{4} \) inch for 100 psf live load or \( \frac{1}{240} \) of clear span, whichever is smaller. Weight of grating or plate segments should be limited to 80 pounds maximum, unless otherwise noted.

m. Each equipment item should be mounted on a reinforced concrete equipment base in accordance with applicable codes and the manufacturer’s recommendation. Edges on concrete pump bases should be chamfered with a minimum one-inch chamfer. Anchor bolts should be stainless steel, 300 series minimum. Wedge type or chemical type anchor bolts are not allowed for rotating equipment.

6.3.3 **Underground Structures:** Design criteria includes the following:

a. The wet well should be constructed of shrinkage-control concrete mix with low specific conductivity suitable for wastewater storage structures. Wet well walls and ceiling should be protected with PVC sheet liner embedded in reinforced concrete. Wet well exterior walls should be epoxy coated. Dry well should be constructed of reinforced concrete.

b. Buried structures should be designed to resist flotation without wall friction resisting the outside surfaces when the wet well is empty. Groundwater should be assumed to be at the surface. A factor of safety (against buoyancy) of 1.10 for 100-year flood condition should be used for design purposes. For normal conditions, the factor of safety should be 1.50.

c. Access doors to the wet well should be provided. All internal areas of the wet well should be visible from the access doors. Hatches should be installed with either safety webbing across the hatch opening or removable handrails that can be placed in chocks around the opening, according to the District’s M&O preference. A stairway for access into an underground pump station dry well should be installed in lieu of a ladder.

d. Areas around any confined space entry should be designed to be suitable for use with the District’s retrieval equipment. Permanent access ladders and manhole steps should not be installed in wet wells.

e. Waterproofing should be provided on the exterior buried walls of non-hydraulic structures and water stops should be installed at all concrete construction joints. Seals at piping and conduit wall penetrations into the station should be watertight.
6.4 MECHANICAL DESIGN CRITERIA

6.4.1 Pump stations and ancillary facilities should conform to the latest edition of all applicable local, state, federal regulations, and industry standards including:

a. California Plumbing Code (County of Sacramento adopted edition)
b. American Society of Refrigeration and Air Conditioning Engineers (ASHRAE)
c. State of California Energy Conservation Standards Title 24
d. NFPA 820, Fire Protection in Wastewater Treatment Plants
e. NFPA 30, Flammable Liquids

6.4.2 A discussion of pump station mechanical components includes the following: a) pump and driver selection; b) piping system materials selection; c) valves in wastewater service; and, d) station cleaning, drain, and washdown facilities.

6.4.3 Pump and Driver Selection: Wastewater pumping is a dynamic process involving discrete but interacting components, including pumps, drivers, piping, and control systems. To achieve a reliable, robust station design, a realistic balance among the system components is required. The mechanical design process should begin with a thorough analysis of the pump operating criteria considering the following:

a. Discharge head versus flow throughout the anticipated operating range
b. Net positive suction head (NPSH) requirements
c. Desired level of reliability
d. Power consumption
e. Life cycle costs (TCO)
f. Ease of operations and maintenance
g. Training requirement for operators and mechanics

A discussion of these factors in pump and driver selection follows below.

a. Categories of Pump Stations by Size: As presented earlier, pump stations in the District are classified according to size (capacity and pump driver horsepower). The breakdown of small, medium, and large pump stations is summarized in Table 6-1.
In general, small pump stations are to be standardized to the greatest extent possible (i.e., common template). Medium and large size stations, with potentially greater risks, should be customized to suit the particular circumstances being considered.

b. Pump Station Capacity Requirements: Capacity requirements include flow and discharge head parameters. Each is discussed below.

(1) Hydraulic Design Capacity: Station design flow rates are based on Average Dry Weather Flow (DWF) and Peak Wet Weather Flow (PWWF).

(2) Discharge Head Requirements: Discharge head requirements are determined by:

(a) Static lift requirements – the total elevation that must be overcome by the pumps at high and low sump levels

(b) Force main sizing – the actual inside diameter of the discharge pipelines

(c) Piping materials – ductile iron, concrete, cylinder pipe, HDPE, PVC

(d) Piping layout – all the relevant fittings that can create pressure loss

(e) Hazen-Williams “C” factor (see below)

(i) The Hazen-Williams equation, “C” factor greatly influences the pump discharge head requirements, and it warrants special consideration.

(ii) As stated earlier, the District has standardized on a “C” of 100 as the design basis for long term use. Pumps must be designed to operate adequately under such a condition. Pipeline frictional losses increase over time, resulting from fouling by biological materials. This “C” factor of 100 represents the terminal condition of pipelines after many years of service.

(iii) The Consultant must also give special attention to the “C” factor for a new force main. To avoid pump “run-out”, the system head curves should be analyzed with typical Hazen-Williams “C” factors for the selected piping material. Specifically, a “C” value of 145 should be used for new pipes.

(iv) For reference, pump “run-out” is a term used to describe excessive flow through a pump such that the NPSH requirements are violated, resulting in pump cavitation and mechanical damage. Because of low piping frictional loss, the pump literally pumps too much flow, to the point that the suction system cannot keep up. Bubbles form inside the casing, only
to collapse as the pressure increases through the impeller. This collapsing of bubbles causes vibration and erosion, and a pump can be severely damaged in a short time.

c. Considerations in Pump Selection: Considerations in pump selection include a discussion of the following:

1. Pump Efficiency: Both pump and wire-to-water efficiencies should be evaluated in selecting a manufacturer’s pump offering. Pump efficiency is the criteria used to assess pump performance both hydraulically and mechanically. Wire-to-water efficiency is required to assess expected annual operating costs. It is important to evaluate a slightly higher efficiency pump driven by a standard efficiency motor versus a slightly lower efficiency pump driven by a high efficiency motor.

2. Wastewater pumps are typically “non-throttled”, meaning that pressure control valves are not installed at the pump discharge to regulate the flow. Instead, the pumps will “ride” the system head curve. Non-throttled operation is recommended to avoid debris plugging the pump discharge. To control the flow, the pumps are operated either with on-off level control (C/S operation) or through speed control (V/S) to maintain level.

3. For small pump stations, a single pump should be selected to handle all normal flows. A single stage, submersible, C/S pump installed on guide rails is recommended. A full-capacity standby pump should be furnished.

4. The preferred design for a medium capacity pump station uses submersible pumps, either wet well or dry pit mounted. Multiple pumps in parallel are typically required to accommodate the range of required flow rates from average DWF to PWWF. Consider the following guidelines in selecting pumps to minimize station size:
   
   a. Attempt to accommodate the PWWF with two duty pumps;
   
   b. Attempt to accommodate the average DWF with one duty pump;
   
   c. Provide one standby pump equal to 50% of the PWWF for medium risk pump stations and 100% of the PWWF for high risk pump stations;
   
   d. Limit the number of pump sizes to preferably one, but no more than two, to reduce required spare parts inventory.

5. For large pump stations, multiple pumps in parallel are typically required. Pump selection should consider the following:
(a) Convey average DWF with two or three duty pumps;

(b) Convey PWWF with three to five duty pumps;

(c) Provide standby pumps equal to 50% of the PWWF for medium risk stations and 100% of the PWWF for high risk stations.

(6) Where V/S pumps are selected, the control scheme should be designed to maintain a nearly constant wet well level, typically in a lead-lag, load-sharing arrangement. The lead pump will operate alone whenever the influent rate is less than the single pump maximum flow rate (up to 95% speed). Above the lead pump maximum speed, additional pumps will be sequenced on to maintain the wet well level.

(7) For a large capacity pump station, lateral and torsional critical speed analyses should be performed to determine critical speeds for either C/S or V/S pumps; especially when floor-mounted pumps are used with extension shafts. In general, no operating speed should be considered within 10% of any critical speed.

(8) An initial pump selection can be made based on a number of mechanical design criteria itemized below:

(a) The range of required flow rates from average DWF to PWWF should typically lie between 60% to 115% of the capacity of the selected pump at its best efficiency point (BEP), the so called preferred operating range.

(b) The required pump discharge head can be achieved with an impeller diameter smaller than the maximum impeller diameter for the selected casing.

(c) The pump should have a head–capacity curve that rises continuously from its BEP to shutoff.

(d) The pump should be capable of passing solids equivalent to a sphere of 3-inches in diameter.

(e) The Net Positive Suction Head Available (NPSH_A) should exceed the Net Positive Suction Head Required (NPSH_R) by a margin of at least 35% at the maximum flow condition.

(f) Pump mechanical design features such as casings, wear rings, and impellers options should be evaluated.
Pump efficiency and “wire to water” efficiency should be identified at the typical operating points.

Each of these criteria is further discussed below.

(a) Preferred Operating Range for Pumps: For pump selection, the Preferred Operating Range (POR) for typical pump conditions should be between 60% to 115% of pump capacity at its BEP. Pump mechanical design is usually optimized within this operation range. This limitation is imposed to avoid two undesirable pump operating ranges. As pump capacity is reduced, the total differential head across the pump increases to a maximum at shut off. This reduction in flow rate increases both the radial and axial loads imposed on the pump shaft. Increased shaft loading decreases bearing and seal life, can cause excessive wear ring damage, and, in the worst case, result in shaft fatigue failure. In addition, permanent cavitation damage can occur below 60 % of the pump BEP due to recirculation and fluid heating within the pump, with a corresponding adverse impact on pump performance. If pump capacity is increased beyond 115% of the capacity at BEP, both a marked increase in radial thrust and cavitation again become serious concerns.

(b) Impeller Diameter: Do not use the maximum available impeller for the casing size chosen. If used, future expansion will require changing the entire pump, not just the impeller.

(c) The Pump Head Capacity Curve: The pump head-capacity curve must be continuously rising from the best efficiency capacity to shutoff. This provides for stable pump operation. Avoid pumps with flat pump curves (i.e., where a small change in total dynamic head will result in a large change in pump flow). An unstable pump curve is one where the greatest total differential head across the pump occurs at a flow rate greater than zero. Instability usually occurs in pumps having a low suction specific speed, \( N_S <1000 \), low capacity, and high head requirement. Other comments are as follows:

(i) As a guideline, the pump head-capacity curve for a small station pump, operating alone and not in parallel, should rise a minimum of 20% from its rated point to shutoff.

(ii) For pumps operating in parallel, the combined performance curve flattens as the number of pumps increases, with the slope of the combined operating curve inversely proportional to the number of pumps. Consequently, maintaining a 20% head rise to shut off for the combined curve, requires an increase in head rise to shut-off for each pump in direct proportion to the number of operating pumps. In general,
the greater the number of pumps operating in parallel, the greater the desired head rise to shut-off for each pump.

(d) Solids Handling Capability: The District standard for solids handling capability is 3 inch, maximum. Directionally, the larger the pump solids handling capability, the fewer the number of impeller vanes. The fewer the number of vanes, the greater the bearing loads and the potential for damaging vibration. In general, a three-vane impeller is preferred. Conversely, in low flow designs this may not be possible.

(e) Net Positive Suction Head: The NPSH\textsubscript{A} should exceed the NPSH\textsubscript{R} by a margin of at least 35% at the maximum flow condition. The Consultant should note that the Hydraulic Institute (HI) defines NPSH\textsubscript{R} as the point at which the pump experiences a 3% drop in TDH as the suction is throttled. The onset of cavitation has proven to occur well before this point and can actually be far more damaging even at a 1% TDH loss.

(f) Pump Speed: The TDH developed by a pump is a function of the impeller tip speed. The tip speed is directly related to both the impeller diameter and the impeller rotational speed. Consequently, the system head-capacity requirements can be satisfied by more than one pump size. One might have a larger impeller operating at lower speed while the next has a smaller impeller rotating at higher speed.

The advantages of a higher speed pump are 1) a reduction in pump casing and motor frame size, resulting in reduced capital cost; and 2) an increase in pump efficiency, reducing annual operating costs. The increase in pump speed however must be balanced with consideration of the potential abrasive wear caused by solids content. The maximum rotational speed for sewage pumps is often given as 1200 rpm for small pumps, and less than 1200 rpm for larger capacity pumps. However, the District has experienced satisfactory operation with small capacity pumps operating at 1800 rpm nominal speed. These factors should be considered by the Consultant during preliminary design in selecting driver speed.

(g) Pump Mechanical Design Features: Several additional mechanical design features are appropriate for consideration by the Consultant including:

i) casing design; ii) the design of casing and impeller wear rings, and, iii) impeller disc design. Each is discussed below.

(i) Casing Design – Single versus Double Volutes: Most sewage pumps have a single volute casing, and are designed to operate within a narrow range on either side of the pump BEP. The single volute design has a single cutwater (see Figure 6-4). As pumping conditions change due to a load variance or change in the system head curve toward either shut-off...
or run-out, the unbalanced radial thrust loads increase rapidly, causing shaft deflection and premature wear of the seals, bearings, wear rings, and impeller. The double volute casing divides the flow discharging through the impeller into two similar geometric regions by including a second cutwater 180° from the first (see Figure 6-4). The net effect of this modification is the balancing of radial loads acting on the pump shaft throughout the capacity range of the pump. Radial loads are reduced by an order of magnitude from those in a single volute design. Double volute casings have been available from several manufacturers for many years. They have not gained widespread acceptance in the industry due to a perceived increase in fouling tendency on the leading edge of the second cutwater. However, where double volute casings have been used in raw sewage applications, there has been no evidence to support any difference in fouling tendency between single and double volute designs.
**SINGLE VOLUTE DESIGN**

The normal single volute design has high unbalanced radial thrust on shaft and impeller, causing shaft deflection and premature wear of seals, bearings, wear rings, and impeller.

**DOUBLE VOLUTE DESIGN**

The double volute design is superior due to opposing radial thrust forces on the shaft and impeller, resulting in much lower radial loads, longer life, lower maintenance, and quieter operation. Double volute is standard on 3" and larger pumps.

![Diagram showing comparison of radial force vs. design capacity with single and double volute](image)

**Typical Comparison of Radial Force vs. Design Capacity with Single and Double Volute**
(ii) Wear Ring Design: To maximize pump efficiency, recirculation at the eye of the impeller must be minimized. To accomplish this, the clearance between the impeller and the casing should be restricted to a few thousandths of an inch. This restricted area should be fitted with replaceable wear rings (stainless steel is recommended) on both the impeller and casing. These rings can be designed to seal in the radial direction, axially, or a combination of the two. A pump design with axial wear rings is preferred because of the increase in radial loading and shaft deflection when a pump is operated outside of the preferred region.

Axial wear rings have the advantage of being adjustable in the field without requiring disassembly of the pump. Conversely, radial wear rings require no axial adjustment, but cannot be adjusted for wear and must be replaced when leakage becomes objectionable. Capability for future water flushing of wear rings, however, should be provided.

(iii) Impeller Disc Design: Vertical centrifugal pumps must be designed for the axial loads that result from the weight of the rotating element(s) and the axial load due to the differential pressure across the impeller. Several techniques are used to reduce dynamic impeller pressure load. One approach provides a hydro-dynamically balanced impeller, where pressure relief holes are drilled in the impeller disc to reduce the pressure acting on the downstream face. This technique has the disadvantage of permitting recirculation.

A more desirable approach is to incorporate four radial ribs into the design of the downstream face of the disc. The ribs have the effect of pumping liquid out of the cavity between the disc and casing, thereby reducing the pressure acting on the downstream face.

d. Driver Selection: The pump selected by the Consultant should be non-overloading. The brake horsepower required by the pump at the manufacturer’s maximum flow rate should not exceed the motor nameplate horsepower rating at a 1.0 service factor. The Consultant should specify that each pump is tested using the actual drive unit and that the pump manufacturer is responsible for furnishing the adjustable frequency drive, for matching the motor and drive, and for coordinating the collection of data and the design effort to limit harmonics.

Unless overriding operability concerns exist, or wet well size is limited, the District prefers drivers to be C/S, with V/S used only when necessary, particularly for small and medium pump stations. As an example, a pumping system designed with multiple C/S pumps may be preferred versus fewer large capacity V/S pumps for a medium size pump station. There are advantages and disadvantages to each design (as summarized in Table 6-7), that should be carefully reviewed by the Consultant in the
station design development process. It is unlikely that C/S pumps would be selected for a large pump station.

### TABLE 6-7
**COMPARISON OF CONSTANT SPEED VERSUS VARIABLE SPEED PUMPING OPERATION**

<table>
<thead>
<tr>
<th>Variable Speed (V/S)</th>
<th>Constant Speed (C/S)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages:</strong></td>
<td><strong>Advantages:</strong></td>
</tr>
<tr>
<td>1. Less capacity required resulting in a smaller, shallower wet well</td>
<td>1. A wide range in operating flow rates can be achieved using a larger number of less expensive and more reliable constant speed drives</td>
</tr>
<tr>
<td>2. Fewer, larger, pumps are needed reducing station space requirements</td>
<td>2. Surges due to starting and stopping one pump are not as severe</td>
</tr>
<tr>
<td>3. Energy savings are likely due to higher average wet well level, usually lower pumping rates, and lower piping frictional losses</td>
<td>3. Less complex equipment, simpler maintenance, greater reliability</td>
</tr>
<tr>
<td>4. The high in-rush current that characterizes across the line starting of C/S drivers is greatly reduced</td>
<td>4. Higher wire-to-water efficiency because of the lack of VFD energy losses</td>
</tr>
<tr>
<td>5. Continuous pumping and short residence times reduce or eliminate 1) deposition of organic solids, 2) putrefaction, 3) the production of odors and corrosive gasses, and 4) the cyclic rise and fall of wet well water level that pumps sewer gases to the atmosphere.</td>
<td>5. Simple instrumentation</td>
</tr>
<tr>
<td>6. Gradual changes in flow reduce hydraulic transients and potential upsets at downstream treatment facilities</td>
<td>6. Quieter operation with less heat generation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disadvantages:</th>
<th>Disadvantages:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increased complexity and capital cost, more equipment and maintenance, and reduced reliability</td>
<td>1. Larger wet wells for C/S pumping may be more expensive because excavation costs are site dependent</td>
</tr>
<tr>
<td>2. Specialized maintenance personnel training is required for each type of variable speed drive</td>
<td>2. Greater number of pumps required to cover anticipated flow range</td>
</tr>
</tbody>
</table>
TABLE 6-7 (Continued)
COMPARISON OF CONSTANT SPEED VERSUS VARIABLE SPEED PUMPING OPERATION

<table>
<thead>
<tr>
<th>Variable Speed (V/S)</th>
<th>Constant Speed (C/S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disadvantages:</td>
<td>Disadvantages:</td>
</tr>
<tr>
<td>3. Potential motor burn out or reduced motor life if variable speed drives are not used and the station is operated at constant speed</td>
<td>3. Difficult to control hydraulic transients without provisions for surge control</td>
</tr>
<tr>
<td>4. Lower electrical efficiency than constant speed drives</td>
<td></td>
</tr>
<tr>
<td>5. Avoiding vibration is more difficult because the “windows” for avoiding resonance are narrower</td>
<td></td>
</tr>
<tr>
<td>6. Instrumentation must normally be more refined, accurate and costly</td>
<td></td>
</tr>
<tr>
<td>7. Rapid changes in technology can quickly make control equipment obsolete</td>
<td></td>
</tr>
<tr>
<td>8. V/S drives are noisier than constant speed drives</td>
<td></td>
</tr>
<tr>
<td>9. Adjustable frequency drives are more susceptible to lightning and electrical disturbances</td>
<td></td>
</tr>
</tbody>
</table>

6.4.4 Piping System Materials Selection: In selecting piping system materials the Consultant should consider piping materials currently used by the District as summarized in Table 6-8 below.

TABLE 6-8
PIPING MATERIAL SELECTION FOR SEWAGE PUMP STATIONS

<table>
<thead>
<tr>
<th>Service</th>
<th>Material</th>
<th>Allowable Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity Sewer</td>
<td>Vitrified Clay (VCP)</td>
<td>Up to 48-inches</td>
</tr>
<tr>
<td></td>
<td>Reinforced Concrete (RCP) with PVC liner</td>
<td>Up to 120-inches</td>
</tr>
<tr>
<td>Force Mains</td>
<td>Ductile Iron, fused epoxy lining, encased in polyethylene</td>
<td>Up to 60-inches</td>
</tr>
</tbody>
</table>
### TABLE 6-8 (Continued)

**PIPING MATERIAL SELECTION FOR SEWAGE PUMP STATIONS**

<table>
<thead>
<tr>
<th>Service</th>
<th>Material</th>
<th>Allowable Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyvinyl Chloride (PVC)</td>
<td></td>
<td>Up to 48-inches</td>
</tr>
<tr>
<td>High Density Polyethylene (HDPE)</td>
<td></td>
<td>Up to 36-inches</td>
</tr>
<tr>
<td>Storm Drain</td>
<td>Non-reinforced concrete pipe</td>
<td>4 to 36 inch</td>
</tr>
<tr>
<td>Potable Water (cold)</td>
<td>Copper Tubing, Type L (Exposed)</td>
<td>Up to 3-inch</td>
</tr>
<tr>
<td>Potable Water (hot)</td>
<td>Copper Tubing Type K (Buried)</td>
<td>Up to 3-inch</td>
</tr>
<tr>
<td>Non-Potable Water</td>
<td>Ductile Iron, Cement-mortar lined, bituminous coating or PVC (Buried)</td>
<td>3- to 24-inch</td>
</tr>
<tr>
<td>Hypochlorite</td>
<td>CPVC, Sch 80</td>
<td>12-inch and smaller</td>
</tr>
<tr>
<td>Hypochlorite Tubing</td>
<td>Reinforced PVC tubing</td>
<td>1-inch and smaller</td>
</tr>
<tr>
<td></td>
<td>Slipline (tubing support) piping: Sch 40</td>
<td>2-inch</td>
</tr>
<tr>
<td>Instrument Air</td>
<td>TP-304L Tubing</td>
<td>3/8-inch to 1-inch</td>
</tr>
<tr>
<td>Foul Air</td>
<td>FRP, thickness = 0.125 inch</td>
<td>6-inch through 20-inch</td>
</tr>
<tr>
<td></td>
<td>thickness = 0.187 inch</td>
<td>21-inch through 36-inch</td>
</tr>
<tr>
<td></td>
<td>thickness = 0.250 inch</td>
<td>37-inch and larger</td>
</tr>
<tr>
<td>Drain</td>
<td>Sch 40 Galvanized Steel</td>
<td>less than 2 inch</td>
</tr>
<tr>
<td>Vent</td>
<td>Cast Iron Soil Pipe, hub and spigot, bituminous coating</td>
<td>2-inch to 6-inch (buried)</td>
</tr>
<tr>
<td>Fuel</td>
<td>Steel, A53B</td>
<td>Through 5-inch</td>
</tr>
</tbody>
</table>

Other piping system design guidelines include the following:

a. All piping should have bonding for continuity.

b. Nylon insulation bushings should be installed between all dissimilar metals in piping (i.e., brass fittings connected to manifolds), between pumps and inlet, and discharge piping, so as to insulate from inductance current caused by motors.

c. Insulation couplings and flanges should be installed to isolation piping and building.

d. Short-sweep 90 degree elbows should be minimized.

6.4.5 Valves in Wastewater Service: Valves size should comply with the maximum velocity criteria for pump suction and discharge piping. Design criteria for valves in wastewater service are presented below. Valve and gate descriptions are included for: a) sluice gates;
b) knife gates; c) eccentric plug valves; d) gate valves; e) swing check valves; and, f) valve actuators. A discussion is also provided of valve access requirements.

a. Sluice Gates  Usage of sluice gates should be limited to inlets to wet wells and partition walls between wet wells. Sluice gates should meet the requirements of AWWA C501, *Cast-Iron Sluice Gates*, be of a self contained design and generally be constructed of 316 stainless steel with ultra high molecular weight polyethylene (UHMWPE) side and top seals. Resilient seats for flush bottom gates should be neoprene. Frame gaskets of EPDM not less than 0.5 inch thick are recommended.

b. Knife Gates:  Usage should be limited to isolated applications where a hydraulic head is less than 20 feet and space is restricted. The major drawback of a knife gate valve is the large sealing area required around the gate. Where used, knife gates should be a resilient seated design of cast 316 stainless steel construction.

c. Eccentric Plug Valves:  Eccentric plug valves have been used as a manually operated isolation valve in vertical lines (valve stem horizontal). District operating experience to date has not been satisfactory, and continued use of this valve is not recommended.

d. Gate Valves:  Gate valves can be used as manually or electrically operated isolation valves in horizontal lines with valve stems oriented vertically upwards to 45°. Various types of gate valves are described below.

1. Resilient Seat Gate Valves, 3 to 12 inch Diameter: Use of an OS&Y NRS (exposed) or NRS (buried), full port, cast iron valve body and gate with Styrene Butadiene Rubber (SBR) resilient seats in sizes 3 inches to 12 inches is recommended. Gate valves should comply with AWWA C509, *Resilient-Seated Gate Valves for Water Supply Service*. Fusion bonded epoxy coating is required on both interior and exterior surfaces.

2. Resilient Seat Gate Valves, 14 to 30 inch Diameter: Use of a NRS, full port, ductile iron valve with bonded SBR ductile iron gate and Buna N stem seals in sizes 14 inches to 30 inches is recommended. Valves should comply with AWWA C500, *Standard for Metal-Seated Gate Valves for Water Supply Service*, and AWWA C509, *Resilient-Seated Gate Valves for Water Supply Service*. Fusion bonded epoxy coating is required on both interior and exterior surfaces.

3. Rotating Double Disc Gate Valves, 14 to 60 inch Diameter: Full port, rotating, double disc valves, complying with AWWA C500, *Standard for Metal-Seated Gate Valves for Water Supply Service*, with ductile iron body, bonnet and wedges, and low zinc body seat rings can be used from 14 inches to 60 inches as an alternative to resilient seated gate valves. The valve should be designed to permit replacement of discs without removal of the valve body from the line. A 6 inch flushing port, 2 inch blow off port and optional bypass valve port should
be cast into the body. The valve design should allow complete replacement of the stem packing under pressure when the valve is either fully opened or fully closed.

e. Swing Check Valves: Air cushioned, counterbalanced swing check valve should generally be provided. The valve should be either cast iron or steel with a replaceable bronze or Buna N seat ring. The counter balance arms should be equipped with limit switches to communicate disc position through the control system. The air dashpot should permit field adjustment of the valve closure rate. Oil control may be required to prevent valve slam particularly where hydropneumatic tanks are used in the station design to control hydraulic transients. Swing check valves should be mounted in horizontal piping only. Check valves should be located outside the wet well.

f. Pump Control Valves: Ball valves may be used as surge, check and pump control valves as required by the system hydraulic transient analysis. While the flow characteristics of eccentric plug valves may be attractive in this application, poor operating experience to date precludes their use. Pump control valves should be either hydraulically or electrically operated. In either case, the control system must provide sufficient stored energy to fully cycle control valves twice at rates required by the system hydraulic transient analysis in the event of electrical power failure.

g. Valve Actuators: A two inch square nut with extension stem should be provided as required for burial depth in a cast iron or plastic valve box. Generally, handwheels for manually operated gate valves should be furnished. Gear operators will be required for gate valves 20 inches and larger. Chain actuators are required for valves 6 feet or higher from the finished floor to valve centerline.

Electric motor operators are often used on sluice gates, but may also be required on gates or pump control valves. Where provided, electric motor actuators should be specifically designed for valve operator service. For example, a 3/60/480, TENV motor should be furnished with Class F insulation designed for Class B temperature rise, thermal overload protection, positive clutch mechanism to engage or disengage the handwheel, 120 VAC space heaters, torque limit switches, and a control station including open/close push buttons and indicating lights and remote/local switch.

h. Valve Access Requirements: All valves should be installed so that sound ergonomic principles are applied. Designs must comply with all OSHA and CalOSHA applicable ergonomic rules in effect at the time of engineering. Specifically:

1. Valves must be easily accessible, with adequate clearances so that operators can work with and around them.

2. Installing valves that require operation with chain operators should be minimized. In general, valves should not be more than six feet above ground (see Figure 6-5).
6.5 HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

6.5.1 Guidelines for pump station HVAC design include the following:

a. Electrical rooms (MCCs, etc.), dry wells, and control centers should be ventilated at a rate sufficient to provide 6 complete air changes per hour. The fresh air at the pump station site should be considered a “G3- Harsh” environment as defined by ISA-S71.04 Standards. The HVAC system should be designed to deliver air complying with the ISA “G1 – Mild” for electrical rooms, dry wells, and control rooms.

b. Separate ventilation systems should be provided for the wet well and dry well. Interconnections between the dry well and wet well ventilation systems are not allowed.

c. Triple filtration to remove contaminants (pre-filter at 10 microns, carbon filter, and 1 micron high efficiency filtration) should be provided.

d. Ventilation openings should be screened with a sufficiently fine mesh to prevent entry by birds, rodents, snakes and insects.

e. Louver face air flow velocities should be approximately 700 ft/min. Scrubber duct air flow velocities should be approximately 800-1,500 ft/min. Ventilation duct air flow velocities should be approximately 700-1,000 ft/min. Conditioned air duct velocities should be approximately 500-1,000 ft/min.

f. Cooling must be provided for electrical rooms and generator spaces (interior rooms and exterior enclosures) to limit room temperature to not more than 85°F during equipment operation. Both heating and cooling should be provided for control room to maintain 70°F to 75°F over the range of summer to winter atmospheric design conditions. In the pump room, cooling should be provided only if required for motor heat rejection. Maximum room temperature should be 95°F ± 5°F.
6.6 ELECTRICAL AND INSTRUMENTATION DESIGN CRITERIA

6.6.1 A discussion of pump station electrical and instrumentation components includes the following: a) electrical facilities configuration criteria; b) emergency power design elements and sizing criteria; c) fuel storage and transfer systems; d) pump station equipment selection and control criteria; e) pump station control room arrangement criteria; and f) facility lighting, intrusion detection, and fire detection.

6.6.2 Electrical Facilities Configuration Criteria: Issues in electrical facility configuration include selection of equipment and arrangement of facilities to achieve the reliability and redundancy necessary, based on the size of the pump station and the level of associated risk. This necessary reliability and redundancy requires examination of pump station facilities arrangements by the Consultant to minimize or eliminate single points of failure. The criticality of individual components is then evaluated to determine the impact of the time required to repair or replace failed components. To facilitate this review, the pump station size and risk matrix described earlier in Chapter 6.1 is used. Pump stations are described as small, medium, or large, based on installed pumping capacity and are divided into high, medium, and minimal risk categories. The effects of pump station classification on design criteria are described as follows.

a. Nominal Voltage Selection Criteria: Nominal voltage selection for a pump station is based primarily on pump station size. Small and medium size pump station nominal voltage shall be 480 volt, three phase. Large pump stations nominal voltage will be either 480 volt or medium voltage, three phase. The selection of either 480 volt or medium voltage for pump station service is a function of the available utility service voltages, connected pumping capacity, and the economics of motor and switchgear costs for various medium voltages. Some typical medium voltages are: 2,400; 4,160; 7,200; 12,470; 17,000; 21,000; and 34,500 volts. The 480 volt or medium voltage service voltage and pump service voltage selection should be addressed during preliminary design and will be subject to review and approval by the District.

b. Reference Drawings – Electrical Facilities Configuration: The following reference drawings are provided to illustrate typical electrical facilities configurations which are appropriate for the size and risk level of the pump station. Size and risk levels are defined in the pump station size and risk matrix (see Chapter 6.1). The facility configurations shown are illustrative only of the level of reliability and redundancy sought for each type of pump station in the matrix. Alternative configurations may be considered or allowed by the District.

[Figure 6-6] One Line Drawing - Small, Minimal Risk Pump Stations
[Figure 6-7] One Line Drawing – Small, Medium Risk Pump Stations
[Figure 6-8] One Line Drawing – Small, High Risk Pump Stations
[Figure 6-9] One Line Drawing – Medium, Medium Risk Pump Stations
[Figure 6-10] One Line Drawing – Medium, High Risk Pump Stations
6.6.3 Emergency Power Design Elements and Sizing Criteria: Emergency electrical service is a consideration for all pump stations. As a minimum, provisions for connection of a portable emergency generator are to be provided at even the smallest, lowest risk pump stations. Higher risk and larger pump stations will feature in-place emergency generator(s) and automatic transfer switch(es) with full bypass capability, to provide the necessary reliability and redundancy in emergency power for the size and risk level associated with the pump station.

Issues in selection of proper emergency electrical service elements by the Consultant include consideration of the necessary unit sizing and redundancy, audible noise limitation, fuel storage and protection needs, unit capacity to serve non-linear loads (if necessary), and any special features or arrangements to facilitate operation, maintenance, and load testing of the units. The prime considerations for emergency electrical service is that the system should be on line and providing service within a very short period (approximately 10 seconds) after loss of normal utility service, and that unit fuel storage must be located on-site.

Due to concerns of earthquake or other natural disasters, emergency units relying on off-site fuel sources are not considered as emergency electrical services. This eliminates natural gas as a source for either gas turbines or gas reciprocating engines. On-site storage of propane is also ruled out due to necessary tank size, propane explosive hazards, and the high cost of a propane engine. Emergency electrical services utilizing commonly available diesel fuel provides the most practical alternative for on-site storage.

Reciprocating engines and fuel cells are emergency sources that use diesel fuel. In practical consideration, the diesel reciprocating engine is the only alternative that can currently meet the size, reliability, and availability requirements necessary for pump station emergency service. Fuel cell technology is progressing rapidly and should be reevaluated periodically by the Consultant for its capability of meeting design objectives while potentially reducing audible noise, run time limitations, objectionable odor and smoke associated with diesel reciprocating engines.
FEATURES

- One full capacity landing lugs for portable gen. w/interlocking breakers.
FEATURES

- ONE FULL CAPACITY ENGINE GENERATOR
- ONE FULL CAPACITY ATS SWITCH WITH BYPASS
- ONE FULL CAPACITY MTS SWITCH RATED FOR THE STANDBY GENERATOR

NOTES

1. PROVISION CONNECTION OF A PORTABLE LOAD BANK, ONLY IF STANDBY GENERATOR IS NOT SUPPLIED WITH AN INTEGRAL LOAD BANK.
2. A FULL CAPACITY LOAD BREAK NON-FUSIBLE DISCONNECT SHALL BE PROVIDED WHERE SHOWN WHEN THE SOURCE BREAKER FEEDING THE MOTOR BUS IS LOCATED IN A SEPARATE SWITCHBOARD. THE DISCONNECT SHALL BE LOCKABLE IN THE OPEN POSITION TO PREVENT BACK FEED CONDITIONS.

LEGEND

- STARTER
- CIRCUIT BREAKER
- K KEYED INTERLOCK
- N.C. NORMALLY CLOSED
- N.O. NORMALLY OPEN
- M MOTOR
- POWER TERMINAL BLOCKS IN A NEMA JR ENCL.
FEATURES
- ONE FULL CAPACITY ENGINE GENERATOR
- ONE FULL CAPACITY ATS SWITCH WITH BYPASS
- ONE FULL CAPACITY MTS SWITCH RATED FOR THE STANDBY GENERATOR

NOTES
1. PROVISION CONNECTION OF A PORTABLE LOAD BANK, ONLY IF STANDBY GENERATOR IS NOT SUPPLIED WITH AN INTEGRAL LOAD BANK.
2. A FULL CAPACITY LOAD BREAK NON-FUSIBLE DISCONNECT SHALL BE PROVIDED WHERE SHOWN WHEN THE SOURCE BREAKER FEEDING THE MOTOR BUS IS LOCATED IN A SEPARATE SWITCHBOARD. THE DISCONNECT SHALL BE LOCKABLE IN THE OPEN POSITION TO PREVENT BACK FEED CONDITIONS.
FIGURE 6–9
SEWAGE PUMP STATION DESIGN MANUAL
PSDM
ELECTRICAL FACILITIES ARRANGEMENT
MEDIUM PUMP STATION / MEDIUM RISK

FEATURES

- ONE UTILITY MAIN SERVICE WITH BREAKER
- ONE FULL CAPACITY ENGINE GENERATOR
- ONE FULL CAPACITY ATS SWITCH WITH BYPASS
- ONE MCC

NOTES:

1. LOAD BANK WITH MAIN CIRCUIT BREAKER.
2. A FULL CAPACITY LOAD BREAK NON–FUSIBLE DISCONNECT SHALL BE PROVIDED WHERE SHOWN WHEN THE SOURCE BREAKER FEEDING THE MOTOR BUS IS LOCATED IN A SEPARATE SWITCHBOARD. THE DISCONNECT SHALL BE LOCKABLE IN THE OPEN POSITION TO PREVENT BACK FEED CONDITIONS.
FIGURE 6-10
SEWAGE PUMP STATION DESIGN MANUAL
PSDM
ELECTRICAL FACILITIES ARRANGEMENT
MEDIUM PUMP STATION / HIGH RISK

NOTE: ALL ATS SWITCHES WITH MAINTENANCE/BYPASS FEATURE
(NOT SHOWN FOR SIMPLICITY)

FEATURES
- TWO FULL CAPACITY UTILITY TRANSFORMERS
- A DOUBLE ENDED MAIN SERVICE WITH TIE BREAKER
- ONE FULL CAPACITY ENGINE GENERATOR WITH EGEN SWITCHBOARD
- TWO PHYSICALLY SEPARATE FULL CAPACITY ATS SWITCHES WITH BYPASS
- ONE PHYSICALLY SEPARATE MTS SWITCH RATED FOR THE MOTOR BUS
  IT SERVES.
- ONE DOUBLE ENDED MCC WITH TIE BREAKER

NOTES:
1. LOAD BANK WITH MAIN CIRCUIT BREAKER
2. MAY BE A SLIDING MECHANICAL INTERLOCK BETWEEN ADJACENT CIRCUIT BREAKERS
3. ALARM ON FAILED TO TRANSFER OR POSITION DISAGREEMENT BETWEEN ATS SWITCHES.
4. A FULL CAPACITY LOAD BREAK NON-FUSIBLE DISCONNECT SHALL BE PROVIDED WHERE SHOWN
   WHEN THE SOURCE BREAKER FEEDING THE MOTOR BUS IS LOCATED IN A SEPARATE SWITCH-
   BOARD. THE DISCONNECT SHALL BE LOCKABLE IN THE OPEN POSITION TO PREVENT BACK FEED
   CONDITIONS.

LEGEND
□ STARTER
□ CIRCUIT BREAKER
k KEYED INTERLOCK
N.O. NORMALLY CLOSED
N.C. NORMALLY OPEN
M MOTOR
▲ POWER TERMINAL BLOCKS IN A NEMA 3R ENCLOSURE.
FIGURE 6-11 - 480 VOLTS
SEWAGE PUMP STATION DESIGN MANUAL
PSDM
ELECTRICAL FACILITIES ARRANGEMENT
LARGE PUMP STATION / MEDIUM RISK

NOTE: ALL ATS SWITCHES WITH MAINTENANCE/BYPASS FEATURE (NOT SHOWN FOR SIMPLICITY)

FEATURES:
- TWO FULL CAPACITY UTILITY TRANSFORMERS
- A DOUBLE ENDED MAIN SERVICE WITH TIE BREAKER
- ONE OR MORE ENGINE GENERATORS TO SERVE PUMP STATION FULL CAPACITY WITH ONE EGEN SWITCHBOARD
- TWO PHYSICALLY SEPARATE FULL CAPACITY ATS SWITCHES WITH BYPASS
- ONE PHYSICALLY SEPARATE MTS SWITCH RATED FOR THE MOTOR BUS IT SERVES.
- ONE DOUBLE ENDED MCC WITH TIE BREAKER

NOTES:
1. LOAD BANK WITH MAIN CIRCUIT BREAKER. IF MORE THAN ONE GENERATOR'S SUPPLIED, LOAD BANK WILL BE SIZED FOR LARGEST GENERATOR AND CONNECTED TO THE EGEN BUS VIA CIRCUIT BREAKER.
2. MAY BE A SLIDING MECHANICAL INTERLOCK BETWEEN ADJACENT 480V MOLDED CASE CIRCUIT BREAKERS.
3. ALARM ON FAIL TO TRANSFER POSITION DISAGREEMENT BETWEEN ATS SWITCHES.
4. IF MORE THAN ONE GENERATOR IS SUPPLIED, EACH GENERATOR CIRCUIT BREAKER WILL BE NORMALLY OPEN WITH SYNCHRONIZING CONTROLS SUPPLIED TO SYNC. EACH GENERATOR TO THE GENERATOR BUS.
5. A FULL CAPACITY LOAD BREAK NON-FUSIBLE DISCONNECT SHALL BE PROVIDED WHERE SHOWN WHEN THE SOURCE BREAKER FEEDING THE MOTOR BUS IS LOCATED IN A SEPARATE SWITCHBOARD. THE DISCONNECT SHALL BE LOCKABLE IN THE OPEN POSITION TO PREVENT BACK FEED CONDITIONS.
FEATURES:
- TWO FULL CAPACITY UTILITY TRANSFORMERS
- A DOUBLE ENDED MAIN SERVICE WITH TIE BREAKER
- ONE OR MORE ENGINE GENERATORS TO SERVE PUMP STATION FULL CAPACITY WITH ONE EGEN SWITCHBOARD
- TWO PHYSICALLY SEPARATE FULL CAPACITY PUMP LOAD BUSSES WITH ELECTRICALLY INTERLOCKED MAIN BREAKERS WITH FULL ATS FUNCTIONALITY
- ONE PHYSICALLY SEPARATE MTS SWITCH RATED FOR THE MOTOR BUS IT SERVES.
- ONE DOUBLE ENDED MCC WITH TIE BREAKER

NOTES:
1. LOAD BANK WITH MAIN CIRCUIT BREAKER. IF MORE THAN ONE GENERATOR'S SUPPLIED, LOAD BANK WILL BE SIZED FOR LARGEST GENERATOR AND CONNECTED TO THE EGEN BUS VIA CIRCUIT BREAKER.
2. IF MORE THAN ONE GENERATOR IS SUPPLIED, EACH GENERATOR CIRCUIT BREAKER WILL BE NORMALLY OPEN WITH SYNCHRONIZING CONTROLS SUPPLIED TO SYNC. EACH GENERATOR TO THE GENERATOR BUS.
3. ALARM ON FAIL TO TRANSFER POSITION DISAGREEMENT BETWEEN ATS SWITCHES.
FEATURES

- TWO SEPARATE UTILITY SOURCES FROM DIFFERENT SUBSTATIONS
- TWO FULL CAPACITY UTILITY TRANSFORMERS
- TWO PHYSICALLY SEPARATE MAIN SERVICES TIED VIA A PHYSICALLY SEPARATE TIE BREAKER SWITCHBOARD.
- ONE OR MORE CAPACITY ENGINE GENERATORS TO PROVIDE FULL PUMP STATION CAPACITY AND ONE OR MORE ENGINE GENERATORS TO PROVIDE STANDBY SERVICE FOR THE FULL PUMP STATION CAPACITY.
- TWO PHYSICALLY SEPARATE EGEN. SERVICES TIED VIA A PHYSICALLY SEPARATE EGEN. TIE BREAKER SWITCHBOARD.
- TWO PHYSICALLY SEPARATE FULL CAPACITY ATS SWITCHES WITH BYPASS (TO SELECT BETWEEN NORMAL AND EMERGENCY POWER) AND ONE SET OF INTERLOCKED BREAKERS TO SELECT FROM EITHER OF THE TWO SEPARATE SOURCES.
- THREE SEPARATE VFD BUSES (ONE FOR EACH SOURCE AND ONE TIE BUS).
- TWO SEPARATE MCC'S WITH A SEPARATE TIE BREAKER SWITCHBOARD.

NOTES:

1. LOAD BANK WITH MAIN CIRCUIT BREAKER. IF MORE THAN ONE GENERATOR'S SUPPLIED, LOAD BANK WILL BE SIZED FOR LARGEST GENERATOR AND CONNECTED TO THE EGEN BUS VIA CIRCUIT BREAKER.
2. IF MORE THAN ONE GENERATOR IS SUPPLIED, EACH GENERATOR CIRCUIT BREAKER WILL BE NORMALLY OPEN WITH SYNCHRONIZING CONTROLS SUPPLIED TO SYNC. EACH GENERATOR TO THE GENERATOR BUS.
3. ALARM ON FAIL TO TRANSFER POSITION DISAGREEMENT BETWEEN ATS SWITCHES.
4. MAY BE A SLIDING MECHANICAL INTERLOCK BETWEEN ADJACENT 480V MOLDED CASE CIRCUIT BREAKERS.
5. 4-WAY INTERLOCK WITH THREE KEYS.
6. A FULL CAPACITY LOAD BREAK NON-FUSIBLE DISCONNECT SHALL BE PROVIDED WHERE SHOWN WHEN THE SOURCE BREAKER FEEDING THE MOTOR BUS IS LOCATED IN A SEPARATE SWITCHBOARD. THE DISCONNECT SHALL BE LOCKABLE IN THE OPEN POSITION TO PREVENT BACK FEED CONDITIONS.
FEATURES
- TWO SEPARATE UTILITY SOURCES FROM DIFFERENT SUBSTATIONS
- TWO FULL CAPACITY UTILITY TRANSFORMERS
- TWO PHYSICALLY SEPARATE MAIN SERVICES TIED VIA A PHYSICALLY SEPARATE TIE BREAKER SWITCHGEAR.
- TWO OR MORE ENGINE GENERATORS ON EACH EGEN SWITCHGEAR, CAPABLE OF SERVING PUMP STATION FULL CAPACITY.
- TWO PHYSICALLY SEPARATE EGENS SERVICES TIED VIA A PHYSICALLY SEPARATE EGENS TIE BREAKER SWITCHGEAR.
- TWO PHYSICALLY SEPARATE FULL CAPACITY PUMP LOAD BUSSES WITH ELECTRICALLY INTERLOCKED MAIN BREAKERS WITH FULL ATS FUNCTIONALITY AND ONE SET OF INTERLOCKED BREAKERS TO SELECT FROM EITHER OF THE TWO SEPARATE SOURCES.
- THREE SEPARATE VFD BUSSES (ONE FOR EACH SOURCE AND ONE TIE BUS).
- TWO SEPARATE MCC'S WITH A SEPARATE TIE BREAKER SWITCHBOARD.

NOTES:
1. LOAD BANK WITH MAIN CIRCUIT BREAKER. IF MORE THAN ONE GENERATOR'S SUPPLIED, LOAD BANK WILL BE SIZED FOR LARGEST GENERATOR AND CONNECTED TO THE EGEN BUS VIA CIRCUIT BREAKER.
2. IF MORE THAN ONE GENERATOR IS SUPPLIED, EACH GENERATOR CIRCUIT BREAKER WILL BE NORMALLY OPEN WITH SYNCHRONIZING CONTROLS SUPPLIED TO SYNC. EACH GENERATOR TO THE GENERATOR BUS.
3. ALARM ON FAIL TO TRANSFER POSITION DISAGREEMENT BETWEEN ATS SWITCHES.
4. 4-WAY INTERLOCK WITH THREE KEYS.
Engine-generator systems should be specified by the Consultant to satisfy local air emission standards. Installations should be designed to provide necessary cooling and heat rejection capability for the standby generator to operate at its full output capacity for any 24-hour period, without overheating or reduction in rated unit life. When installed indoors, necessary heat balance calculations should be prepared for radiated heat from the engine-generator and auxiliaries, as well as interior ambient temperatures. When installed outdoors, engine-generators shall be rated for their full capacity as noted when installed in their required sound attenuated, oversized outdoor enclosures, in the expected site ambient temperature conditions.

Engine-generators should be installed to provide good working clearance around the engine-generator. When installed indoors, engine-generators shall be provided with twice the NEC required working space for the full length of both sides and the generator end of the unit. When installed outdoors, engine-generators shall be located to provide twice the NEC required working space around all four sides of the unit. Oversize outdoor enclosures, which are designed for walk-in accessibility, should also provide full NEC required working clearance around the interior of both sides and the generator end of the engine-generator enclosure.

Additional design criteria are presented below.

a. Criteria for Emergency Power Configuration - Small Pump Stations (See Figures 6-6, 6-7, and 6-8): Small pump stations as a minimum should have provisions for connection of a portable generator. Medium and high risk stations should also have an in-place emergency generator and automatic transfer switch with key interlocked bypass breakers. Small pump stations with permanently installed emergency generators should have a double-walled fuel tank installed within the base of the unit. This has the advantage of minimizing the footprint required while elevating the unit for improved access for maintenance. Installation of a generator base tank should never result in the generator mounting height to cause electrical or mechanical components, or replaceable parts to be located more than 54 inches above the finish floor (for indoor units), or the base of the generator concrete mounting slab (for outdoor units). Capacity of indoor unit base tanks shall not exceed the 660 gallon limit of NFPA 101, Life Safety Code.

When installed outdoors, permanent emergency generators should be supplied in sound attenuated oversize enclosures. Units for both indoor and outdoor application should be equipped with ‘critical’ grade silencers. Permanent emergency generators should be equipped with a generator breaker installed at the unit, automatic start controls coordinated with the automatic transfer switch, and standard alarms and indication wired to the remote terminal unit (RTU). A manual transfer switch should allow use of the permanently installed generator, or a portable generator brought on-site. This will facilitate work on, or removal of, permanent generators needing repair or replacement.
b. Criteria for Emergency Power Configuration - Medium Pump Stations (See Figures 6-9 and 6-10): All medium size pump stations should have a permanently installed full capacity emergency generator and automatic transfer switches with key interlocked bypass breakers. Parallel, full capacity automatic transfer switches are to be provided for high risk pump stations. A manual transfer switch will allow use of this permanently installed unit, or a portable generator brought on site.

Installed outdoors emergency generators should be supplied in sound attenuated oversized enclosures. Both indoor and outdoor units should, as a minimum, be equipped with “critical” grade silencers. Where specifically required (for noise sensitive applications) “hospital” grade silencers should be supplied. Emergency generators should be equipped with a generator breaker installed at the unit, automatic start controls coordinated with the automatic transfer switch, and standard alarms and indication wired to the RTU.

Emergency generators should be provided with a generator full capacity, multi-step, resistive load bank, with a separate main circuit breaker connected on the load side of the generator breaker. A power monitor should be supplied to provide data on power parameters, power quality, and harmonics. Fuel tanks for emergency generators should be “protected” double-walled, above ground tanks, with all necessary auxiliaries as discussed. Fuel tanks installed within the mounting base of the unit are not permitted.

c. Criteria for Emergency Power Configuration - Large Pump Stations (See Figures 6-11, 6-12, 6-13, and 6-14): Large pump stations, as a minimum, should have a permanently installed full capacity emergency generator. High risk pump stations should have two full capacity emergency generators. Parallel, full capacity automatic transfer switches with key interlocked bypass breakers should be provided at all large pump stations.

Installed outdoors emergency generators should be supplied in sound attenuated oversized enclosures. Both indoor and outdoor units should, as a minimum, be equipped with “critical” grade silencers. Where specifically required (for noise sensitive applications) “hospital” grade silencers should be supplied. Each emergency generator should be equipped with a generator breaker installed at the unit, automatic start controls coordinated with the automatic transfer switch, and standard alarms and indication wired to the RTU.

Each emergency generator should be provided with a generator full capacity resistive load bank with separate main circuit breaker connected on the load side of the generator breaker. A power monitor should be supplied to provide data on power parameters, power quality, and harmonics. Fuel tanks for emergency generators should be double-walled, above ground tanks, with all necessary auxiliaries as discussed later in this chapter. Fuel tanks installed within the mounting base of the
units are not permitted. As a minimum, a separate fuel tank should be provided for each generator supplied.

d. Summary of Electrical Service Requirements: A summary of proposed pump station electrical features and service requirements is provided in Table 6-9.
<table>
<thead>
<tr>
<th>Pump Station Size</th>
<th>Small</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pump Station Risk Level</strong> No. of Run Pumps</td>
<td>Minimal</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>One pump</td>
<td>One pump</td>
<td>One pump</td>
<td></td>
</tr>
<tr>
<td>One pump (DWF)</td>
<td>One pump (DWF) + one pump (PWWF)</td>
<td>As required (minimum of 100% PWWF capacity)</td>
<td></td>
</tr>
<tr>
<td><strong>No. of Standby Pumps</strong></td>
<td>One pump (same capacity as run pump)</td>
<td>One pump (same capacity as run pump)</td>
<td>One pump (same capacity as run pump)</td>
</tr>
<tr>
<td>One generator (PWWF capacity) + provisions for portable generator</td>
<td>One generator (PWWF capacity) + provisions for portable generator</td>
<td>Number of generators as required (PWWF capacity)</td>
<td></td>
</tr>
<tr>
<td>Selectable fixed or portable generator source</td>
<td>Selectable fixed or portable generator source</td>
<td>Two utility XFMRS and one double ended SWBD</td>
<td></td>
</tr>
<tr>
<td>AS required (minimum of 50% PWWF capacity)</td>
<td>As required (minimum of 50% PWWF capacity)</td>
<td>Two utility XFMRS and two main switchboards</td>
<td></td>
</tr>
<tr>
<td><strong>Installed Emergency Capacity</strong></td>
<td>None (Provision for port)</td>
<td>One generator (PWWF capacity) + provisions for portable generator</td>
<td>One generator (PWWF capacity) + provisions for portable generator</td>
</tr>
<tr>
<td>Selectable fixed or portable generator source</td>
<td>Selectable fixed or portable generator source</td>
<td>Two utility XFMRS and one double ended SWBD</td>
<td></td>
</tr>
<tr>
<td>One ATS each with full bypass capability</td>
<td>One ATS each with full bypass capability</td>
<td>200% generator capacity and two generators SWBDS</td>
<td></td>
</tr>
<tr>
<td><strong>Electrical Distribution Equipment Redundancy</strong></td>
<td>None</td>
<td>Selectable fixed or portable generator source</td>
<td>Selectable fixed or portable generator source</td>
</tr>
<tr>
<td>Two utility XFMRS and one double ended SWBD</td>
<td>Two ATS each with full bypass capability</td>
<td>Two ATS each with full bypass capability</td>
<td></td>
</tr>
<tr>
<td>100% Redundancy</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Reference Figure</td>
<td>6-6</td>
<td>6-7</td>
<td>6-8</td>
</tr>
</tbody>
</table>

Sacramento County PSDM (Final Submittal)
6.6.4 Fuel Storage and Transfer Systems: The Consultant is responsible for determining and complying with applicable regulations of all local authorities concerning fuel storage and transfer systems. Emergency generation systems and engine driven pumps require on-site fuel storage systems compliant with NFPA 30. Diesel fuel storage requires spill containment to meet or exceed EPA, CalEPA, and local ordnance requirements. All pump station diesel tanks should be double-walled construction, meeting UL 142 and UL 2244. Outdoor, above-ground tanks should be “protected” type compliant with UL 2085. All interconnect piping should be double-walled, plumbed with leak detection sensors at piping low points. Other considerations based on pump station classification are presented below.

a. Criteria for Configuration - Small Pump Stations: Small pump stations with permanent emergency generators should typically have the generator unit supplied with a double-walled in-base tank. The generator will typically be the only user of diesel fuel at the site and provides efficient use of available space. The generator tank should be sized for 24 hour run time based on the expected generator fuel consumption rate.

b. Criteria for Configuration - Medium Pump Stations: Medium pump stations should be supplied with separate “protected” double-walled, above ground, main and transfer (day) tanks. The main tank should be sized for 24 hour run time based on the expected generator consumption rate. The main tank should be equipped with leak detection sensors in the interstitial spaces, wired to a fuel management monitoring system which can monitor main tank level, provide leak detection and remote alarm notification.

The transfer (day) tank should be sized for 4-hour run time based on the expected generator fuel consumption rate. The double-walled tank should be supplied with leak detection sensors in the interstitial spaces wired to the fuel management monitoring system. The transfer (day) tank should incorporate two duplex full capacity pumps operating in alternating mode from a level sensor in the transfer tank to transfer fuel from the main tank. The transfer tank level sensor should also provide tank high, tank low (start second pump) and tank low-low alarms wired to the fuel management monitoring system. Tank low-low should initiate engine stop to prevent air injection into the engine fuel system. (Day tanks may be omitted if only one engine is served from the main fuel tank and the distance from the tank to the engine is less than 30 feet).

All interconnected piping between the main and transfer tanks and the emergency generator should be double-walled pipe plumbed for leak detection sensors at the piping low points. Leak detection sensors should be wired to the fuel management monitoring system for remote alarm local and modification.

c. Criteria for Configuration - Large Pump Stations: Fuel storage and transfer systems for large pump stations should be identical to those described for medium pump
stations. When two or more emergency generators are supplied for a large pump station, each generator should have its own main tank, transfer (day) tank with duplex transfer pumps, and fuel management monitoring system with fully instrumented leak detection in related tanks and piping.

6.6.5 Pump Station Equipment Selection and Control Criteria: Pump station electrical equipment selection by the Consultant should be based primarily on the ability to meet the process demands of the pump station. Additionally, equipment will be required to meet specified limits for vibration, audible noise, harmonic voltage and current and electrical surge immunity. These topics are addressed below.

a. Control: Equipment will be required to have a minimum level of manual control and operability in addition to automatic operation as addressed later in this chapter.

b. Enclosures: Electrical equipment to be located outdoors should be housed in an enclosure suitable for the location. Emergency generator enclosure should be NEMA 3R rated with enclosure thermostatically controlled strip heaters. The enclosure should provide complete access for all onsite maintenance and repair needs without requiring disassembly or removal of the enclosure. Main switchboards, motor control centers, automatic transfer switches, and similar equipment when installed outdoors, should be supplied in NEMA 3R non-walk-in, weatherproof enclosures. NEMA 3R enclosures should be supplied with deadfront, weatherproof pad lockable outer doors providing complete access to interior mounted equipment and all their components. The NEMA 3R enclosure vestibule should be provided with fluorescent lighting and should be sized to allow full opening of equipment interior doors. Where outdoor equipment is front and rear accessible, weatherproof, dead-front, pad lockable, outer doors should be provided on both the front and rear of the equipment providing full access to all interior mounted equipment components and terminations. Thermostatically controlled strip heaters should be provided in all sections of interior mounted equipment.

Where electronic equipment, PLCs, PCs, power supplies, instrumentation, displays or other heat sensitive control equipment are to be located in an outdoor enclosure, the equipment should be grouped together in a control panel or control section of the enclosure. All control panels, or sections with all supplied components, should be designed for continuous functionality and full service life in the ambient internal temperatures the panels will experience when installed. The Consultant should specify that the control vendor verify compliance with this criteria. When supplemental cooling equipment is required to meet this criteria, the equipment should be designed as an integrated system with the overall equipment enclosure. High risk stations requiring supplemental cooling should provide fully redundant cooling systems for all controls and instrumentation critical to pump station operation.
Control panels should be NEMA 4 rated, whether standalone or integrated into a lineup of other equipment in a NEMA 3R non-walk-in enclosure. Control sections that are part of an MCC vertical section are excepted. In those cases only, the control section NEMA enclosure rating can be that of the MCC vertical section.

Other outdoor electrical enclosures such as junction boxes, and enclosures housing control stations, receptacles, light switches, etc. should be as a minimum NEMA 4 rated (NEMA 4X in corrosive environments). Electrical safety switches, whether fusible or non-fusible, should be supplied in NEMA 3R enclosures for outdoor locations.

c. Vibration Limits and Monitoring Criteria: Vibration limits and monitoring for pump stations apply to rotating equipment. Design specification requirements for diesel driven pumps and diesel driven emergency generators shall specify that a torsional analysis for the unit be provided. No field testing or permanently installed vibration equipment is typical for this type of equipment. Similarly, no field testing or permanently installed vibration equipment is typically applied to submersible pumps whether used submerged or in dry pit arrangements. No vibration standards currently give any guidelines for this equipment.

Vibration limits standards are well quantified for vertical motors, whether close coupled or shaft connected to their respective pumps. ANSI Hydraulic Institute Standard 9.6.4 specifies required vibration limits. This standard should also be cited by the Consultant in design specifications. Field testing should be required for verification that design specifications are met for all such main pumps at medium and large pump stations.

Permanent field installation of vibration protection for vertical, non-submersible pumps, should be limited to the application of vibration switches at small pump stations. At medium pump stations, a vibration transducer should be provided for close coupled vertical pumps. A multi-axis vibration monitoring system should be provided for vertical pumps connected by long shafts. At large pump stations, all vertical pumps should be protected by a multi-axis vibration monitoring system.

d. Audible Noise Criteria: Pump station audible noise is most notably caused by pumps, compressors, motors, generators, transformers, and drives. Audible noise can result in damage to hearing as well as generate complaints from adjacent properties. Specific mitigations to be considered by the Consultant are discussed below.

(1) Placement of Equipment: Equipment placement can mitigate audible noise concerns. Audible noise generating equipment located inside buildings should be segregated from desired low noise areas such as control rooms. Equipment located outdoors, such as diesel pumps, diesel generators, and large transformers should be located based on generating minimum audible noise to adjacent properties.
(2) Noise limits: Manufacturer’s noise limits have been established for certain classes of electrical equipment (principally transformers). Also, OSHA limits very high decibel audible noise that can damage human hearing. These noise limits should be specified for the applicable equipment and adhered to in the design of pump station and its facilities. The most stringent audible noise limits are those imposed by local ordinance at the property boundary. The Consultant should design and verify compliance with audible noise limits at the property line imposed by local ordinance, under all pump station design operating conditions.

(3) Noise Attenuation: Limiting audible noise to acceptable levels can be a function of both the specified equipment and the implementation of sound attenuating techniques. These techniques include construction of sound walls and baffles, the use of sound attenuating enclosures and materials, installing high noise equipment in segregated interior rooms, and active sound cancellation. Active sound cancellation is an expensive option with limited application. The type of noise attenuation employed should be reviewed with the District assuming compliance with all audible noise limits required by OSHA and local ordinances in effect at the site.

(4) Interior Areas: Limited entry time areas such as areas containing engine-generators; air compressors; HVAC machinery; and large motors, pumps, transformers, or drives may have damaging levels of audible noise. Compliance with OSHA requirements for the use of hearing protection and limited entry time must be adhered to, and accounted for, in the design for operation and maintenance of equipment located in these areas. Other guidelines include:

(a) General interior areas do not require hearing protection for continuous occupancy.

(b) Control rooms should be designed to encompass instrumentation, control systems, MCCs, distribution switchboards, panelboards and drives. Control rooms should not contain HVAC machinery, pumps, motors, or large transformers. Air compressors should be limited to instrument air units for bubbler level controls and should be mounted in enclosures. Distribution transformers for lighting and low voltage power are acceptable if they comply with NEMA ST-20 audible noise standards.

(c) For the purpose of determining allowable noise levels for peak and cumulative exposure, pump station control rooms shall be considered as a 24-hour a day continuous occupancy area. Under no circumstances shall the design of the control room require occupants to wear hearing protection for prolonged exposure. Where necessary VFD drives, MCC, distribution
transformers, etc., shall be located in an electrical room separate from the control room.

e. Harmonic Voltage/Current Limits and Monitoring Criteria: The proliferation of general electronic equipment with switch mode power supplies, along with high power electronic equipment such as solid state starters and variable frequency drives has caused harmonics to become an issue to both the serving utility and their customers. These devices, which draw load current in a non-linear fashion, cause distortion in the utility’s voltage wave form. This distorted voltage wave form can then cause harmonic currents to flow to other utility customers on the same distribution circuit, even if those customers have no electronic equipment at their facility. Utilities are understandably concerned when a customer’s connected electronic equipment can cause malfunction of equipment in another customer’s facility. Utilities have generally adopted the requirements of IEEE 519 for the maximum allowable harmonic distortion allowed at the utility service point (referred to in IEEE 519 as “the point of common coupling”). IEEE 519 places limits on THD (Total Harmonic Distortion) of the voltage wave form and TDD (Total Dynamic Distortion) of the current wave form allowed at the point of coupling. The stated position of utilities is generally that these standard limits must be met, but do not address corrective measures or who pays for them. At the point of common coupling current distortion (TDD) is a reflection of the facility’s non-linear loads and is the facility’s responsibility. Voltage distortion (THD) relates to the “stiffness” of the utility source and is the utility’s responsibility provided that the facility current TDD is within limits. Utilities generally do have language allowing them to suspend service to facilities exceeding these limits.

All new pump station facilities as well as pump station refurbishment projects should be designed to IEEE 519 standard requirements at the point of common coupling with the utility. This means that a harmonic study needs to be performed by the Consultant as part of the design process for medium and large pump stations, when high power electronic equipment (solid state starters and variable frequency drives) is to be used on some or all of the main pumps. This harmonic study needs to model the utility source, emergency generator source, and the major loads served by high power electronic drives and by standard drives). The study will specify that corrective measures be taken as necessary to meet the IEEE 519 limits at the point of common coupling with the utility. Corrective measures to reduce the impact of harmonics are discussed further in this chapter. The effectiveness of the corrective measures should be verified initially by modeling within the harmonic study. Final verification will be confirmed by witnessed field test under actual operating load conditions, with any additional measures to be designed, installed, and retested to verify compliance with IEEE 519. Harmonic limits when the pump station is running on the emergency generator source are discussed below.

(1) Harmonics and Emergency Power: A local emergency generator will always be less “stiff” than the utility source. Therefore, when operating non-linear loads
on generator, the local voltage distortion (THD) will be greater than when operating on utility power. Excessive THD can result in malfunction of the generator voltage regulator or of the driven equipment. Often the same equipment (VFDs, computers, UPSs, power supplies, etc.) which create the non-linear current (TDD) will malfunction as the system voltage distortion (THD) becomes excessive.

Pump station design must assure compatibility of the emergency generator with the driven loads. Oversizing of generators and specifications of voltage regulators with high tolerance to voltage distortion may be required to meet the design target THD level when operating on the emergency generator. Other harmonics mitigation as discussed below can also be applied. Design specifications should require that the system voltage THD remain below an allowable limit (recommended THD maximum of 10%) when operating on an emergency generator. This should be verified initially during design by harmonic modeling of the emergency generator and facility loads by the Consultant. Startup testing under actual load conditions should be required to verify operation within the specified harmonic limits, with mitigating measures to reach the limits implemented at that time.

(2) Harmonic Distortion from VFD Equipment: VFDs, if applied, will be the most significant non-linear load at a pump station. Standard arrangements and options include 6 pulse, 12 pulse, 18 pulse (higher number drives are available for large, medium-voltage VFDs), isolation transformers and reactors for line terminal, load terminal, and DC bus. Selection of appropriate VFD arrangement and options by the Consultant should be considered with regard to IEEE 519 limits and operability while connected to the emergency generator.

Mitigation of “reflected wave phenomena” at the VFD output will be required for all cable distances greater than 50 feet between the VFD and the motor. All motors for VFD duty should be “inverter duty” per NEMA MG-1. VFD output reactors, high voltage rated cable, and suppresser “motor terminators” will also be required, if necessary, to achieve proper operation of the system.

(3) Technologies for Harmonic Reduction: A number of technologies are currently employed to reduce the presence of harmonic distortion at various locations in an electrical system. These are described below for Consultant consideration.

(a) The most elementary of the harmonic reduction technologies simply adds inductive reactance in the form of a line reactor or isolation transformer at the input to a major harmonic source such as a VFD. These devices do not actually eliminate harmonics but instead concentrate them on the load side of the inductive reactance. This is an acceptable method of harmonic isolation for VFD use at small pump stations, but does result in heating in motor cores and a potential reduction in motor life.
(b) A technology used for many years for harmonic suppression is the application of tuned passive filters. These filters consist of capacitor, inductor, and resistor elements tuned to a given harmonic (5th harmonic, 300 Hz or 7th harmonic, 420 Hz for example). These passive filters have drawbacks; they become less effective if the harmonic character of a load changes. They also are very sensitive to resonant conditions which can cause spectacular and dangerous failures of their capacitive elements. In general, passive filters are not recommended for application at pump stations.

(c) Another technology used to suppress harmonics is the application of active filters. Active filters constantly monitor the current distortion waveform and inject a current waveform identical but 180° out of phase with the current distortion waveform essentially eliminating harmonic distortion. This technology is very effective and can easily adjust to changes in the character of the harmonic source. This technology is most cost effective when used to reduce or eliminate harmonic distortion on existing VFD installations.

(d) The preferred technology to suppress harmonics from VFDs applied at medium and large pump stations is the use of multi-pulse VFD drives (18 pulse or greater). These drives eliminate almost entirely the 5th and 7th harmonics which are the most troubling. They do introduce some higher order harmonics (11th and 13th) but these are of small magnitude relative to the level of 5th and 7th harmonics generated by standard 6-pulse VFD drives.

(f) Surge Protection and Monitoring: Criteria for surge protection are discussed below.

(1) Surge Protection Application at the Main Service: Surge protection of the incoming utility service is essential for proper protection of pump station electrical facilities. Surges on the utility feeder can occur from lightning strikes, capacitor switching, or other switching events on the utility system.

Pump stations receiving service at 480 volts have some limited degree of protection due to the inductive reactance of the utility transformer reducing the rate of rise of surges on the utility feeder, but this alone is insufficient protection. Distribution class surge arresters of the metal oxide varistor (MOV) type, should be installed at the main service for pump stations receiving service at 480 volts. The recommended location is at the load side terminal of the 480 volt main breaker. Locating the arresters on the line side of the main breaker would give some additional surge protection to the main breaker, but at the risk that a failed arrester (short to ground) would have to be cleared by blowing the utility transformer’s high side fuse, potentially resulting in extensive damage to the main service prior to blowing of this fuse. With the arrester installed on the load side of the main breaker, a failed arrester would be cleared much more quickly with a minimum of damage.
Larger pump stations receiving service at medium voltages direct from a utility feeder without an intervening transformer have greater exposure to surges on the utility system. For this reason “intermediate” class arresters of the MOV type are recommended for installation at these pump stations. Arresters should be installed at the load terminals of the facility main breaker.

(2) Protection of Emergency and UPS Circuits: Exposure of the emergency generator source to surges is fortunately more limited then that of the incoming utility source. Due to the critical nature of the emergency source, MOV arresters are recommended at the generator, on the load side of the generator breaker. This location would allow maximum protection to the generator from incoming surges, while allowing the generator breaker to trip on a failed arrester (short to ground) with minimum stress on the generator’s windings. Distribution class arresters are recommended for 480 volt generators while intermediate class arresters are recommended for all medium voltage units.

Uninterruptible power supplies (UPS) have very little exposure to surges. The risk of losing critical controls and instruments due to an arrester failure at a UPS is a considerable risk. Surge protection for individual control and instrument circuits are discussed below, and is a more practical location for the application of surge protection. Applying surge protection to a UPS would unnecessarily create an unacceptable “single point of failure” due to potential arrester failure.

(3) Surge Protection and Isolation of Instrument Circuits: Surge protection should be applied on all control and instrument loops which extend beyond the confines of the control room or outdoor control panel, depending on station configuration. All instrumentation loops extending beyond the control room or outdoor control panel should have signal isolators installed on these loops (at the control panel). MOV arresters should be installed on the field side of these isolators. MOV arresters should be selected with sufficient threshold to eliminate signal bleed.

(4) Surge Monitoring on Normal and Emergency Power Services: All medium and large pump stations should have individual surge monitors on both the normal and emergency power sources. This surge monitoring should be a function of the power monitoring system, described elsewhere in this chapter. The power monitoring system should provide capture of sags, swells, and spikes on the monitored service.

g. Minimum Equipment Manual Controls: “Hand-Off-Auto” (HOA) switches should be applied for all main pump controls at all pump stations. The operation under “auto” will be discussed later in this chapter. In “hand”, the controlled pump should be operable by the operator with only those interlocks that are determined to be critical in the circuit. Interlocks that are considered to be critical should be determined by the
Consultant based on District input early in the design process. The “hand” switch position should not bypass any overloads or protective relays.

Test-lockout switches should be applied at each pump and its associated motor location (if located separate from the pump). Test-lockout switches should be installed in control station enclosures, mounted on stanchions or wall surfaces immediately adjacent to the pump or motor. The test button should be a momentary push button to allow “jogging” of the motor. The lockout push button should be pad-lockable in the lockout position.

6.6.6 Pump Station Control Room Arrangement Criteria (see Figure 6-15): Pump station control rooms should be arranged to provide proper working clearances and access to all equipment. Lighting levels and audible noise levels in the control room should comply with the recommendations in this chapter. Pumps, motors, compressors and other high noise equipment should not be located in the control room. Medium voltage equipment and high current equipment (more than 600 amps) other than pump drives, should not be located in control rooms to minimize electrical noise in instrumentation and control circuits. A separate electrical room is recommended for this equipment where necessary.

Control rooms should be arranged for direct viewing of all instrument and control panels. Back-to-back arrangement of panels which cannot be viewed from a central location are not preferred. Preferred equipment arrangement is for front access only panels, installed with backs to walls and grouped according to function. The room center should be left open for an operator’s desk/work station and reference table, with receptacles and phone outlets. The control room, or other secure area, shall also provide a minimum of 8 lineal feet of wall space for the location of lockable storage cabinets suitable for pump station critical small space storage. Instrumentation should generally be grouped together and in proximity to the SCADA panels. Distribution panelboards and related transformers should be grouped together and separated from the instrumentation/SCADA grouping. In new installations, control room conduits should be imbedded in the floor slab with the maximum possible separation between instrument/low voltage control circuits and power conductors (but not less than 12 inches - except at crossings). Instrument/low voltage control conduit and power conduit should not run parallel to each other for more than 25 feet. Crossing of power conduits with instrument/control conduits should always be at right angles. The control room and equipment enclosures in the control room should be arranged to allow future conduit runs to be accomplished overhead, between equipment with top entry into enclosures.
6.6.7 Facility Lighting, Intrusion Detection, Fire Detection: Exterior lighting, interior lighting, intrusion detection, and fire detection are discussed below.

a. Exterior Lighting: Minimum lighting levels should be ½ foot candle at outdoor equipment and the exterior of the pump station control building. Minimal light levels are desired to be maintained at the fence line with approximately ¼ foot candle desired. Where there is a control building, wall mounted light packs are preferred to pole mounted fixtures. Exterior light switching should be manual from interior light switches, with photocell override for daylight shut-off. No timer or motion control of exterior lights is desired.

b. Interior Lighting: Minimum levels are:

(1) Control Room: The Consultant should design 60 foot candles using fluorescent fixtures with energy saving ballasts. Two level switching in control rooms should be provided along with battery backed exit lighting.

(2) Motor/Pump Room: The Consultant should design 40 foot candles using fluorescent fixtures with energy saving ballasts. Two level switching in motor/pump rooms should be provided along with battery backed exit lighting.

(3) Wet Well: Design for 20 foot candles using explosion-proof light fixtures. Battery backed explosion proof exit lighting should be provided.

(4) Machine Rooms/Process Room: Design for 40 foot candles using wet or damp location fluorescent fixtures (as appropriate) with energy saving ballasts. Two level switching in these rooms should be furnished along with battery backed exit lighting.

c. Intrusion Detection and Fire Detection: Criteria for intrusion detection and fire detection are discussed below.

(1) Intrusion Detection: Magnetic door switches on all exterior building doors (or on outdoor control panel exterior doors) wired in series as a discrete input to the PLC in the SCADA panel, with a panel interior override switch, should be provided. Conduits for future installation of fiber optic linked video cameras at pump station building interior and exterior areas should also be furnished.

(2) Fire Detection: Conduit between the control room wall area for instrumentation to stub-outs for fire detection sensors in control room, motor room, pump room, machine/process rooms, storage rooms, bathrooms, and common areas should be provided. The Consultant should coordinate with local jurisdiction to provide required fire protection panel location and installation of necessary sensors, wiring, and sprinkler systems, as required.
6.7 SCADA DESIGN CRITERIA

6.7.1 A discussion of pump station SCADA includes the following: a) standardization of instrumentation and control components; b) level instrumentation; c) pressure instrumentation; d) flow instrumentation; e) power instrumentation; f) hazardous gas instrumentation; g) instrumentation power supplies: h) programmable logic controllers; i) operator interface panel; and j) control strategies.

6.7.2 Standardization of Instrumentation and Control Components: The Consultant must comply with District requirements for instrumentation and control (I&C) systems. Standardization of I&C components and implementation significantly facilitates both operation and maintenance of the stations. With a standard I&C interface, Operators (both locally and via SCADA) can quickly adapt to each station with minimum effort or risk of misoperation. Selection of particular I&C component manufacturers and models eases maintenance, minimizes “mean time to repair,” and reduces spare parts stock. PLC and SCADA communication components must be standard to facilitate integration of new facilities with minimal work.

For Consultant reference, the District may consider changes or upgrades to standardized I&C components in the future, as chosen models become obsolete or as new technology offers significant advantages. At this time, certain options recommended for District consideration are instruments with HART or Foundation Fieldbus protocol. HART is an instrument protocol that allows digital communication to coincide with analog 4-20mA signals. HART is particularly useful for digital instrument configuration and calibration. Current Foundation Fieldbus standard “H1” is a completely digital protocol with series (daisy-chain) connection of instruments on shielded-twisted pair wire. (Future standard “H2” will be Ethernet-based.) Eventual migration to PLCs utilizing industrial-grade Ethernet may be appropriate in conformance with industry-wide trend.

6.7.3 Level Instrumentation: Wet well level is the single most important variable at a sewage pump station. Wet well level instrumentation must be standardized and should be performed with a bubbler system. Criteria are as follows:

a. Each bubbler system should consist of redundant air compressors served from separate AC circuit breakers, a single air storage tank, compressor alternating controls, purge controls, and pressure transmitter.

b. Medium risk pump stations should have a single bubbler system.

c. High risk pump stations should have redundant bubbler systems. Each bubbler system should consist of a single air storage tank, redundant air compressors served from separate AC circuit breakers, compressor alternating controls, purge controls, and pressure transmitter.

d. Stations with multiple wet wells require bubbler systems, as above, for each wet well.
e. Bubbler system compressed air tank should be sized to maintain bubbler system operation for a minimum of 6 hours. The system should include a pressure switch to alarm on air tank low pressure.

f. Wet well high and low alarms should be generated by PLC logic, based on the bubbler pressure transmitter signal.

g. Bubbler pressure (level) transmitter should be the District’s pre-selected manufacturer and model.

h. All bubbler systems should be provided with a manual purge valve to allow an operator or technician to blow clear a clogged bubbler discharge tube.

i. Bubbler components should be installed, piped, and wired in a common enclosure, either wall mounted or free standing, as required by the application.

j. Wet well high-high alarm and pump room, or manhole high alarm instrumentation, should be reactive air type, per District standard. The reactive air bell should be located at the appropriate elevation for flood risk warning, and in a location convenient for testing with a bucket of water. When applied in manholes, the reactive air bell should be located so it can be tested with a bucket on a pole, without requiring personnel entry into the manhole.

k. Cable-suspended transmitters, or float switches, should not be applied for raw sewage level sensing.

l. Float switches may be applied for pump room (dry pit) sump pump control.

m. The pump room sump should include a sump high level alarm to activate before the sump overflows. The pump room should also be provided with a reactive air type for high-high alarm.

6.7.4 Pressure Instrumentation: Guidelines include the following:

a. Pressure transducers on station discharge headers may be appropriate for medium and large pump stations, but should not be applied to small stations. Station discharge pressure indication is useful to corroborate piping hydraulic models. If no station flow meter is provided, station flow can be derived from discharge header pressure in conjunction with hydraulic model information.

b. Pressure switches should be provided for pump high-discharge pressure protection. This is particularly useful to avoid operating pumps with an accidentally shut discharge valve. Pressure switch setting must be determined from the pump
manufacturer’s performance curves. (High discharge pressure switches may not protect a VFD driven pump operating at reduced frequency.)

c. Pressure transducers and switches should be provided with isolators to protect the instrument from the process fluid. For pipe sizes up to 12 inch, isolators of the annular type are preferred. For pipe sizes above 12 inch, pipe taps with standard diaphragm isolation should be applied.

6.7.5 Flow Instrumentation Guidelines:

a. Station flow metering should not be applied for small pump stations.

b. Flow instrumentation may be applied to the discharge of medium and large pump stations. Discharge flow meters should be magmeter type, installed with adequate straight pipe runs up and downstream from the meter to assure accurate indication. Magmeters must be installed in piping that is completely filled when in operation. Magmeters should comply with District standards.

c. Continuous flow metering of individual pumps is not desired. Facilities to allow flow measurement for annual pump performance testing should be considered.

d. Where stations require metering of incoming flows, open channel metering flumes of the Palmer-Bowlus type equipped with ultrasonic level transmitters should be applied. Proper configuration and installation relative to up and downstream piping to allow proper accuracy should be verified by the Consultant.

6.7.6 Power Instrumentation Guidelines:

a. Standardization of electric power instrumentation is appropriate to facilitate use. Multifunction power meters from alternative vendors have significantly different user interfaces. Dial-up access from remote District offices is desired to examine meters on current conditions, download event logs and oscillography reports.

b. Power metering is not desired at small pump stations.

c. Medium and large pump stations power metering should be applied separately on utility and emergency generator service feeders. Metering with harmonics analysis capability is particularly appropriate on stations with VFD pumps. Minimal power data should be transferred to the PLC by analog signal to avoid excessive handling of non-vital data.

d. The District may consider power metering on individual pumps at medium and large stations. Annual efficiency test personnel have expressed a desire for ammeters on pumps to facilitate their testing. The cost of a multi-function power meter is
marginally greater than that for a multi-phase ammeter. Indication of actual power in watts is more appropriate for efficiency calculations than motor current in amperes.

6.7.7 Hazardous Gas Instrumentation Criteria:

a. District policy is that personnel safety for confined-space entry should be assured by portable, hazardous gas “sniffers”, calibrated monthly and “bump-tested” daily.

b. Chlorine leak detection should be applied wherever chlorine gas or sodium hypochlorite is stored or handled. At stations where large quantities of chlorine or hypochlorite are stored, redundant sensors should be furnished.

c. The District does not have a standard implementation for permanently installed hazardous gas monitoring of excess hydrogen sulfide or methane (combustible gas), or lack of oxygen. The District has experienced poor reliability of hazardous gas sensors in wet wells, even when they are not subject to flooding. Should wet well hazardous gas monitoring be applied, sensors may have better longevity if applied with an air sampler pump and tubing system.

6.7.8 Instrumentation Power Supplies: Guidelines include the following:

a. Instrumentation and control systems should be 24VDC powered wherever possible. Station main control panels should include 24VDC batteries and battery charger(s). Batteries should be sealed “valve regulated lead acid” (VRLA) type for optimal safety and minimal risk of acid spillage.

b. At small stations without on-site emergency generators, battery capacity should support the PLC and SCADA communications equipment for 8 to 12 hours, to allow continuous remote monitoring. Wet well level is particularly of concern.

c. On medium and large pump stations (which will be provided with emergency generators) redundant batteries and battery chargers should be applied, each sized for a minimum of one hour of operation. Each redundant battery system should be isolated from the other with a diode bridge. Battery chargers should be provided with dry contact outputs for loss of AC, high DC, and low DC.

d. Fusing should be applied to segregate loads. Fuseholders should be blown-fuse-indicating type to further facilitate troubleshooting.

e. Metal oxide varistor (MOV) surge suppression should be applied to all 24VDC circuits leaving the control panel. Standard terminal block arrangements should be applied.

f. Where essential instruments are not available for 24VDC operation, then a 120VAC UPS should be applied, sized for a minimum of one hour operation.
6.7.9 Programmable Logic Controller (PLC): Each pump station is controlled and/or monitored by a PLC. The PLC provides the central brains with input and output tied to instrumentation and control circuits. The PLC also serves data to a local Operator Interface Panel (OIP) and the remote SCADA system. Design criteria consist of the following:

a. District preference is that sewage pump station PLCs should be Modicon Quantum. All utilized PLC components should be from a District list of allowed devices. Panel terminal blocks should be District preferred type by Phoenix Contact and PLC I/O (input/output) wiring should be per District standard drawings (to be provided to Consultant). This will minimize spare parts requirements and differences between implementations among stations.

b. Minimal and medium risk pump stations should have a single processor, while high risk pump stations should be equipped with dual processors set up in redundant “hot standby” configuration. The “hot standby” arrangement should employ dual cables from each processor to the I/O rack. Where pump station construction employs redundant wet wells, the I/O rack should be arranged in a split backplane configuration for complete separation of redundant I/O.

c. Auxiliary systems such as hypochlorite handling requiring stand-alone PLCs should be implemented with Modicon PLCs, per District requirements.

d. PLC programming should be with ladder logic performed with the District’s preferred programming language. IEC-1131 programming languages (sequential function chart, flow diagram, structured text, etc.) should not be used. PLC logic should follow a program template to minimize variations between stations. Register assignments should be systematically grouped into contiguous registers according to logic, OIP, and SCADA data transfer requirements. Addresses and logic should be rigorously annotated according to District standards.

e. The District may consider implementation of measures preventing “write” instructions into PLC registers except where explicitly allowed for SCADA and OIP commands. Writing of data to erroneous registers is a significant risk in a PLC with network connections.

6.7.10 Operator Interface Panel (OIP): The OIP should be the District’s preferred model. The District is currently reviewing alternatives to the Cutler-Hammer “PanelMate 4000”, currently in use at numerous stations. With the pending District review of the SCADA system, the District may consider implementation of a local OIP that is a local subset of the SCADA implementation. This could involve replacement of a dedicated OIP with an industrial PC or selection of an OIP sharing a common programming language with the SCADA system.
OIP programming should provide alarm annunciation and acknowledgment independently from the SCADA alarm system. Specifically, alarms should remain indicated at the station until acknowledged by a local operator.

Standardization of OIP programming should be required to minimize variations between stations. Screens should be developed from District standard templates. Alarm and event reporting should follow a standard format. Implementation of trend charts on the OIP is recommended allowing the operator to see the recent performance of the station.

6.7.11 SCADA Communication: Pump stations shall be provided with standard components for SCADA communications. Minimal risk stations require radio communication only. Medium and high-risk pump stations should be provided with radio communication and telephone company lease-line for backup.

6.7.12 Control Strategies: Because PLC, OIP, and SCADA programming will not be part of the construction documents, detailed strategies for primary pump station services will not be required during station design by the Consultant. However, an outline of the intended control strategy for the station, along with a narrative of any hydraulic limitations are necessary. Detailed strategies for Contractor-integrated subsystems such as sodium hypochlorite are required by the Consultant. Other highlights are listed below.

a. C/S pumps are preferred, wherever possible, over V/S pumps. Pump selection and wet well capacity must be reviewed for pump start/stop setpoints, while avoiding excessive pump cycling.

b. Stations with combinations of C/S and V/S pumps will require formulation of an appropriate standard control strategy.

c. Stations with multiple VFD pumps are currently implemented with two control strategies:

(1) In the fixed level strategy, a single wet well level is selected. Additional pumps are sequenced on when speed control command for the running pumps exceeds a setpoint (typically 95% speed). All running pumps are paced equally. Pumps are sequenced off when the speed command falls below a low threshold value (typically around 60% speed).

(2) A variable level strategy has been recently implemented at two pump stations (Natomas and Cordova). In the variable level strategy, a level stage with a specific setpoint is assigned to each lead, lag, lag-lag (etc.) pump. Each level stage is assigned three level setpoints in increasing order: stop, setpoint, and start. Higher stages have higher level setpoints. Only the most recently started pump is speed modulated according to a level control PID algorithm. Previously started pumps operate at full speed. This strategy is believed to provide energy savings, due to operating pumps at full speed close to the best efficiency point.
District staff has found this latter strategy to be overly complex and would prefer implementation of the older, fixed level strategy, unless significant energy savings can be demonstrated.